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THE MERCEDES DAM, MEXICO.

By James D. Schuyler,* M. Am. Soc. C. E.

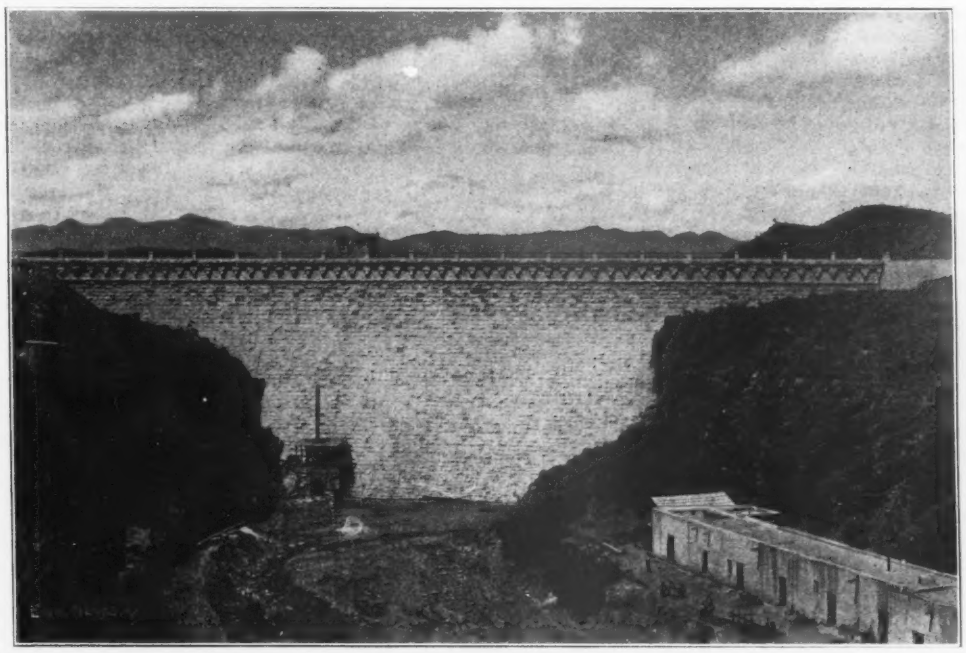
One of the large landed estates of Mexico, in the State of Durango, is the Hacienda de Santa Catalina del Alamo y Anexas, which includes five minor haciendas, or centers of administration, embracing more than one million acres, and belongs to Senor Pablo Martinez del Rio, of Mexico City. While a large part of the estate consists of rugged grazing lands, there are extensive valleys of fertile soil where cotton can be profitably grown. The Nazas River is the source of irrigation supply for a large and extremely fertile territory known as the Laguna District, stretching eastward from the line of the Mexican Central Railway for 50 miles or more. A large part of the cotton crop of Mexico is produced in this district. It has developed into such a profitable industry as to give a high value to all the water supply available for irrigation.

The property of Mr. del Rio adjoins the Laguna District on the west, from which a number of small tributaries of the Nazas River drain the mountainous portion of the hacienda in a northeasterly direction from the region broadly known as the Yerbanis Sierra. One of these tributaries, called Zorrillo Creek, drains an area of 120 sq. miles before passing through a narrow box canyon known as the Boquillo del Zorrillo. Below this canyon there are many thousands of acres of fine land, in a large valley of a stream called La Vieja, which only require a sufficient water supply, applied artificially at the right time, to produce cotton or any other crops in abundance. Immediately above the canyon is a small valley of a few hundred acres, surrounded by hills and adaptable for the formation of a capacious reservoir.

The canyon is not more than 1,800 ft. in length, in the form of a letter S, and at its upper end the width of the canyon between the rocky walls is but 102 ft. at the creek bed. These walls are nearly vertical for 60 to 70 ft. in height and then slope back at an angle of about 2 to 1 on one side and 3 or 4 to 1 on the other.

This site was selected for the construction of a masonry dam, which was begun May 14, 1901, and completed May 8, 1905, forming one of the most notable dams in Mexico and comparing favorably with many of the best-known structures of the world. It is easily accessible by good road, eight miles from the station of Pasaje, on the Mexican International Railway, which is about midway between Torreon and Durango.

The dam has an extreme height from the lowest foundations to the crest of 40.5 m. (132.8 ft.), of which 8.5 m. (27.88 ft.) is below the original creek bed. The thickness of the wall at the top is 3.5 m. (11.48 ft.); at the level of the creek bed, 22.2 m. (72.8 ft.); and at extreme base it is 25.75 m. (84.5 ft.). The profile is of the well-known Wegmann gravity type, based on a specific gravity of two for the masonry. Its cubic contents are 21,416 cu. m. (about 28,000 cu. yds.), and its cost complete was approximately $200,000 Mexican currency. The wall is straight for a little more than half its length, the remainder being curved with a radius of 60 m. (197 ft.), measured from the central axis at the crest, its convex side being up-stream. Its length at base is but 13 ft.; at the creek bed, it is 102 ft. long; 66 ft. above the creek bed it is 256 ft. long, and at the crest its total length is 535 ft., not including the spillway, which is 98 ft. in length and 6½ ft. deep.



THE MERCEDES DAM WITH ACCESSORIES, NEARING COMPLETION, NEAR PASAJE, DURANGO, MEX.

A tunnel, 77.6 ft. long, and 6 ft. × 6 ft. 5 ins. in section, was cut through the rock at the level of the stream bed at the end of the dam, through which the flow of the stream was diverted during construction. This diversion was effected by means of a slender wall, built as a portion of the upper face of the dam, which was founded in bedrock in a trench cut for the purpose. This tunnel was temporarily closed with a wooden bulkhead, but is to be provided with a 24-in. outlet pipe and gate, surrounded by concrete.

To cut off seepage through bedrock underneath the dam, a trench, 1 m. wide, 2.5 m. deep (3.28 × 7.7 ft.) was excavated in the solid rock above the footing of this wall, the rock being plastered with cement and the trench refilled with puddled clay. The remaining excavation for the base of the dam was then made, without molestation from water, and the foundations of the dam were laid with cement mortar for a thickness of 2 m. On the sides, this thickness diminished from 2.0 m. next to the bottom to 0.75 m. at the top. In the body of the dam, hydraulic lime mortar was used, made near its site from an excellent quality of limestone there existing. This was mixed in the proportion of 1 of lime to 2 of sand. The sand used was a clean, sharp quartz sand, found in the bed of a tributary stream some distance above the dam. The Portland cement used amounted in all to 1,800 bbls. It was mixed in the proportion of 1 to 4 of sand, and hence only about 10% of the entire volume of masonry is laid in cement, the remainder being laid with hydraulic lime mortar.

The character of masonry in the body of the dam was an uncoursed rough rubble, but the two faces were built of cut stone, in uniform courses of 0.6 m. (2 ft.) on the lower face and 0.45 to 0.70 m. on the up-stream face. It was estimated that 37% of the mass of masonry consists of mortar.

The stone at the dam site is of volcanic origin, classified as rheolite, which was so brittle and of such irregular cleavage as to be considered unfit for use in the masonry. The stone used in the work was taken from a quarry opened 2 kilometers above the dam. It is an *andesite* or volcanic sandstone formation of a reddish color, which appeared to fill all requirements, as it could be quarried in large blocks and was easily dressed to dimensions required. When tested at the National School of Engineering in Mexico, it was found to have a compressive strength equal to 521 tons per sq. ft.

The main outlet of the dam consists of a cut-stone culvert, 6 ft. wide, 7.87 ft. high, having vertical sides and a semi-circular arched roof. This connects with a rectangular shaft or tower built against the dam on the up-stream side,

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extending from the base to and above the top, the interior dimensions being 1.0 by 1.83 m. The three walls of this tower are 5.1 ft. thick. At the base of the tower on the outside is a 6-ft. circular sluice gate of cast iron, operated by a steel gate stem, 1.75 ins. diameter, and a ball-bearing geared hoisting device, resting on a platform projecting from the tower at the level of the crest of the dam.

Fig. 2. Dam Under Construction, Showing Extent to Which Hand Labor Was Employed.

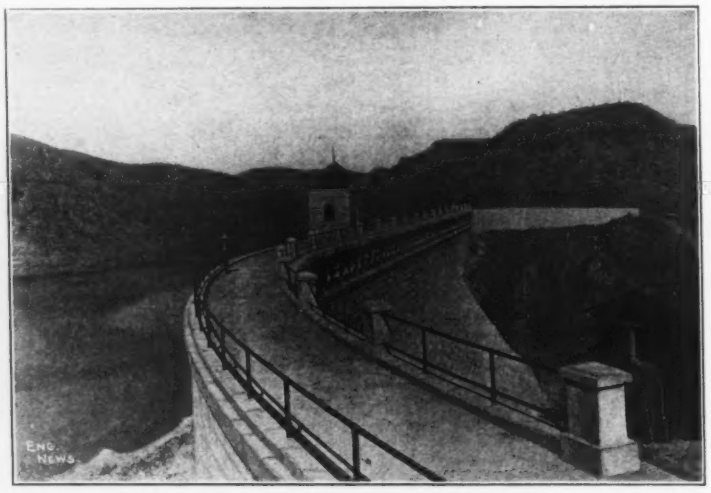

Fig. 3. Dam Completed; Wing Wall for Spillway at Further End.

FIGS. 2 AND 3. VIEWS OF MERCEDES DAM, MEXICO.

On the inside of the tower, against the face of the dam proper, is a similar sluice gate, 5 ft. in diameter, also operated from the top. The method of operating these gates is to fill the tower with water through other smaller openings, while both gates are closed. The outer gate, being relieved of pressure, can then be raised. The inner gate, which can be kept well oiled, as it will be easily accessible, can presumably be easily raised under full pressure, as much as desired. If it were opened wide, the discharging capacity with the reservoir but half full, would be approximately 900 cu. ft. per sec. As it is never intended to draw out more than 40 to 50 sec.-ft. for irrigation at any time, the evident purpose of these huge gates is to provide for a very large discharge at times, to be used in the attempt to wash out silt accumulations from the reservoir, although they are of doubtful value for this purpose. They will probably never be used except when the reservoir is nearly empty.

The main service outlets consist of two flanged-joint 12-in. cast-iron pipes, placed vertically inside the walls of the tower and opening out into the reservoir with six upturned elbows, which are closed with cast-iron covers, lifted from the top by cables. These pipes pass through the masonry of the dam underneath the culvert, and discharge into the cement-lined canal which starts at the base of the dam and is carried through the canyon to the fields below. Gate valves at the lower end control the discharge. The covers on the inlet elbows have hinged 1-in. flap valves, which are raised to admit water for filling the pipes, before the covers are raised, and thus act as by-pass valves. The intake elbows are placed in pairs at depths of 34.4 ft., 62.8 ft. and 91.3 ft. from the top. The four upper ones are in the front wall of the tower and the lower two are on the sides. They connect with the vertical stand-pipes by means of flanged crosses, the free ends of which are closed with cast-iron caps bolted to the flanges.

Two 6-in. by-pass connections, controlled by gate valves, open into the tower at the base of each vertical stand-pipe, through which the tower may be filled behind the 5-ft. sluice gate.

As a precaution against percolation through the dam, the upper face was treated with alternate washes of alum, dissolved in water, and potash soap, five coats of each on the lower third, four coats on the middle third and three coats on the upper section. Application was made by spraying with a hand pump.

The dam was built entirely by native labor, with but few mechanical appliances. The materials were hauled to the site on small cars drawn by mules on a 2-ft. gage tramway, hoisted by animal power up an incline of 24% grade and distributed over the dam by portable tracks, and cars pushed by hand. The mortar was mixed in a vat operated by mule power and located about a mile above the dam, where water was obtained from wells. It was delivered on the same track by which stone was brought from the quarry. During the first year of construction, the work was overtopped by freshets several times, without injury. During the second year, the run-off was very small and the work was not interrupted by floods; in fact, a shortage of water for construction was experienced for a brief period. The dam reached a height of 10 m. (33 ft.) during that season.

At the close of the rainy season in the fall of 1905 the water in the reservoir had reached a height of only 13.5 m. (44 ft.) above the floor of the outlet culvert. With the water standing at this height in the reservoir, dampness and sweating was observed on the down-stream face of the dam, but this completely disappeared a few days later. Leakage through the bedrock at the sides of the dam and into the tunnel continued as long as water remained in the reservoir, although in finely distributed filtrations through minute seams and not in a manner threatening the least danger to the dam.

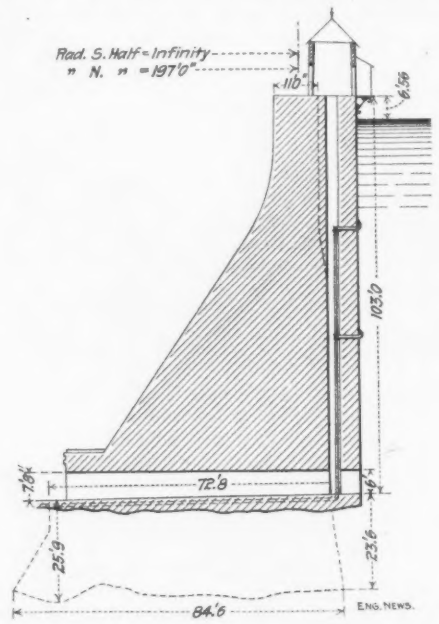

Fig. 4. Section of Mercedes Dam, Taken Through Outlet and Gate House.

By the end of August, 1906, the reservoir was filled to the height of 46 ft., but without the reappearance of moisture on the face of the dam, although the leakage through bedrock seams was renewed in the same amount as before. As the stream carries a large quantity of silt at times, it is expected that the seams in the rock may ultimately be closed by the fine particles of silt drawn into them and finally shut off all further leakage.

WATER SUPPLY.—The discharge of the stream was measured during the time of construction of the dam, as follows: 1901, 4,306 acre-feet; 1902, 26,000 acre-feet; 1903, 2,830 acre-feet; 1904, 8,590 acre-feet; 1905, 5,463 acre-feet; average, 9,438 acre-feet. This is a run-off of 24 to 217 acre-feet per square mile per annum, averaging 78.6 acre-feet per square mile. The rainfall at the dam has been recorded as follows: 1901, 11.65 ins.; 1902, 24.84 ins.; 1903, 16.38 ins.; 1904, 14.80 ins.; 1905, 16.36 ins. The rainy season begins in June and ends in November, the heaviest rains occurring in the month of September, before and after the equinox.

Owing to the precipitous and impermeable nature of the drainage area and the lack of the retarding influences of forests and gravel-filled valleys, the run-off is torrential in character and at times reaches a rate of 7,000 cu. ft. per sec. The drainage area is about 42 miles in extreme length, and the summit elevations more than 3,000 ft. higher than the dam. Owing to the irregularity in rainfall, the water supply is correspondingly fluctuating, amounting to considerably less than the reservoir capacity during four of the five years in which it was measured.

The reservoir floods an area of 416.4 acres, and has a capacity of 12,000 acre-feet.

The spillway of the reservoir was excavated from the solid rock at the north end of the dam to a width of 30 m. (98.4 ft.). The crest is well paved with masonry laid in cement. It is two meters in depth to the crest of the dam. Its capacity is said to be double the amount deduced as essential by observation of the volume and duration of maximum floods and considering the equalizing action of the reservoir capacity in the two meters of depth over the sill of the spillway.

IRRIGATION.—The area of land which may be irrigated from the reservoir has yet to be determined from the observation of catchment during a period of years. If the reservoir could be filled once each year, it would suffice for the irrigation of 5,000 acres. A single crop of cotton produced on this area, with the normal yield of one bale per acre, valued at $50 per bale, would more than repay the cost of the dam. The investment is therefore to be regarded as a profitable one.

SILT.—Observations on the volume of silt brought to the reservoir indicated that at times it might reach as high as 3%. Upon the advice of the author, a partial precipitation of the silt will be made by the building of some small dams

above the main reservoir, as any attempt to sluice it out of the reservoir would only result in a loss of valuable water, without moving more than an inappreciable quantity of the silt which had precipitated over the floor of the reservoir.

CANAL SYSTEM.—The main canal is 2,100 m. (6,900 ft.) in length, mostly lined with masonry. It has a section of 2.75 sq. m. (29.5 sq. ft.) and a grade of 5 ft. in 10,000 (2.64 ft. per mile). From the end of the main canal, a smaller ditch with a section of 1 sq. m. (10.75 sq. ft.), and having the same slope or grade as the main canal, is carried to the south a total distance of 6,500 m. (4.4 miles), while toward the north extends a ditch with a section of 1.8 sq. m. and a fall of 1 per 1,000 for a distance of 1,560 m. This ditch has several drops of 2 to 3 m. (6.5 to 9.75 ft.) built in masonry, and divided into the north and central canals, which have a combined length of 8,600 m. (5.8 miles) as far as completed. These ditches command an area of 5,000 acres, on a portion of which a satisfactory crop of cotton was produced in 1906.

The dam was designed by Carlos Patoni, C. E., of Durango, and the construction was carried out under direction of Carlos Duran, C. E., of Mexico City, to whom the author is indebted for the facts embodied in the foregoing description, as well as to P. Barnetche, the intelligent foreman in more immediate charge of the work.

THE STRENGTH OF STONE AS AFFECTED BY DIFFERENT METHODS OF QUARRYING.

By Francis W. Hoyt.*

In some of the greatest examples of modern construction, architects and engineers have had, comparatively speaking, nothing to guide them. They have been called upon to confront entirely new problems. The novelty and strangeness of the work is found not only in a magnitude hitherto undreamed of, but also in the use of new materials of construction, or of materials that have gone through unusual processes of manufacture. There has not been time, as yet, for the thorough testing of all of these materials. On some of them Nature acts in a totally unexpected way.

Conscientious as engineers and architects may be, it is apparent that in many cases the factor of safety has not been figured out according to the individual conditions. Text books and tables are to be had which give general modes and customary rules for computing masonry stresses. These, however, are merely for general application. To adapt them to particular instances would require long and searching investigation. Time is scarcely ever available for such a course. It is highly desirable, therefore, to bring together all of the general information relative to the strength of materials of construction.

There is very little literature on the strength of stone, and most of it is widely scattered through scores of ponderous government publications. Some of the most important facts of wide bearing have never been gathered into any handbook. Worst of all, a large part of the information closest at hand is seriously misleading because no account has been taken of the great influence of methods of quarrying and finishing upon the natural strength of stone.

Modern construction has changed very largely the burdens put upon masonry. In high buildings most of the load is carried by steel and iron, on which the stress is easily computable. The stone walls are carried up as a mere shell, which has little to carry but its own weight. Often it is relieved even from this, the weight of the wall being borne by the steel-work at various stories. Thrust due to wind pressure is entirely taken up by the metal skeleton. For heavy masonry and ordinary engineering work, however, the stresses stone has to withstand are much the same as they have always been, and new problems seldom present themselves.

In the past undue weight has been given to the crushing strength of stone. Among the stones acceptable for structural work the crushing strength varies from two or three thousand up to nearly 50,000 lbs. per sq. in. In reality, these figures are not of great practical importance. The weakest stone in most situations will bear all of the weight likely to be placed fairly upon it, and the strongest stone may succumb from injuries inflicted in quarrying. Besides this, in order to have any comparative value, all cubes should be prepared and all crushing tests should be made by one man. A cube for testing may be gotten out by a quarry foreman in precisely the same hap-hazard manner that he would use in preparing an architect's sample. A good piece of stone is selected, without any regard as to how it was loosened from its bed. It is roughly pitched and pointed into shape with hard blows from a heavy hammer. It may then be dressed smooth with an 8-lb. to 12-lb. bush-hammer. All of this has a tendency to destroy the cementing material, and loosen the cohesion of the particles, so that half the natural strength may be gone before the cube gets to the testing table. Another man may pick a sample from the same quarry, using every precaution to see that there has been a free break along the rift. Not a single hard blow is struck in bringing it into shape, and it is finally laboriously smoothed on the rubbing bed. What wonder if this sample shows an apparent strength thousands of pounds greater per square inch than the first cube? And yet the engineer would be safer in relying upon the first test, for the preparation of the sample represents more nearly the experience of a hewn stone, after going through the quarrying and dressing process.

It is easy to understand from the preceding illustration the wide variation in the recorded crushing strength of the same stone. To mention but two instances: In the government reports the same California granite has shown a crushing strength of 5,239 lbs. per sq. in. at one test, and 21,104 lbs. at another, and a Georgia granite revealed a variation from 12,190 lbs. to 28,130 lbs. Which of these two figures is the engineer to take?

As a matter of fact, even if one desired to accept the crushing test as a basis of computation, the ultimate strength of the stone should be based upon the appearance of the first crack, and not upon the destruction of the cube. Generally cracking and crushing are practically simultaneous, but sometimes a considerably smaller load is necessary to crack than to crush. In structural work, cracking is the full extent of failure permissible, without substitution or protection. The national government, which has hitherto been insistent upon the crushing test in stone acceptable for use in federal buildings, is now dropping this requirement.

The crushing test assumes a certain importance in the matter of piers. Here the factor of safety is computed for the full section, and yet many times only a part of the area is called upon to bear the entire load. No matter whether the masonry be ashlar or coursed or random rubble, the filling is bound to be laid with less care than the face work. The filling is always of rubble, and the voids are filled in with spawls and chips, thickly bedded in mortar or cement. It needs no argument to prove that, no matter how much care is exercised, the filling settles more rapidly than the face-work, which is of large blocks with thin courses of cement. This means that the load is brought wholly upon the face-work, often a mere shell in comparison with the full section of the pier. Consequently the factor of safety is very greatly reduced, especially where the load is not borne axially.

In this connection it is interesting to consider two of the most notable failures in recent years: When the towers of the Niagara Suspension Bridge were taken down it was found that many of the large blocks of stone were only half bedded, and serious vertical fissures had resulted from the consequent complexity of the stresses. The stone was the compact country limestone, rather friable in nature, but still fully strong enough to bear all the load had the bedding been perfect and the stress equally distributed over the entire area. Again, in the Truro Cathedral, in Cornwall, the facing of the piers is a soft magnesian limestone. Structurally it is one of the weak stones, and it is quarried without regard to the rift, to which I shall refer later. The architect, the late J. L. Pearson, R. A., was too conscientious a workman not to have computed the factor of safety carefully, but he did not foresee that because of the shrinking of the filling, all of the load would come on the thin and weak facing stones. They were totally unable to bear the burden and crumbled away.

With solid brick piers having templates and bases of stone, the load is more apt to be distributed over the entire area contemplated, especially where the stones are firmly bedded by grouting. Besides, the stone used for this purpose is generally of the strongest variety, sandstone or granite, and from its nature it is so quarried as to yield its maximum strength, as will appear later. While almost any of the stones used for structural purposes will bear, when properly laid, any burden that can reasonably be put upon it, one point should never be overlooked in figuring the factor of safety: When the crushing test is applied, the cubes are generally given the most perfect bedding that skill can devise. The bearing faces are ground parallel to the fraction of an inch, and are rubbed with a thin coating of plaster of Paris to fill in all inequalities. This represents a condition that cannot be approximated in masonry. The slightest inequality may cut the registered strength fairly in two, so that it is the part of wisdom to allow a very generous margin in accepting official figures.

In architectural work, many large stones are laid that are only partially bedded, such as lintels, architraves, etc. For such uses, a consideration of crushing strength is wholly out of place. What is important here is the shearing strength. Tests to show this factor have not been conducted as frequently as those for crushing, but they are growing more common as it is realized that this resistance of the stone is of great concern to builders. The test as conducted by army engineers consists in applying to a prism of stone supported at each end by blocks six inches apart pressure from a plunger having a face five inches wide, thus giving a clearance space of half an inch between the sides of the plunger and the blocks on each side below. It will be seen that this approximates the stress on a lintel, for instance, although it is more intense because none of the pressure is applied directly above the bedded portions. The difference between the crushing and the shearing strength of any stone is very marked. For instance, the crushing strength of a hard, dense hornblende granite of Eastern Massachusetts is given in two official tests at 16,000 and 19,750 lbs. per sq. in. each. The shearing resistance of the same stone, as given by two tests, is only 1,052 and 2,047 lbs. per sq. in. The crushing strength of a sandstone from lower Central Massachusetts is 8,812 lbs. per sq. in., and the shearing strength ranges from 992 to 1,383 lbs. per sq. in. A dolomitic marble from lower New York has a crushing strength of 13,076 lbs., while its shearing strength is only 1,554 lbs. per sq. in. A Georgia marble crushes at 13,400 lbs., but shears at 1,501 lbs. Enough tests have not been made to permit of generalization, but it is safe to say that the shearing strength of a stone is but little more than 10% of the crushing strength. If, therefore, computations of the factor of safety for stone-work that is not bedded for its entire length are based upon the crushing strength of a stone (and, as a rule, these are the only figures obtainable), it will be seen that there is abundant opportunity for failure.

A cursory examination of the large buildings in any city will reveal a surprising number of lintels and architraves that have developed vertical cracks. Few of these imperil in the slightest degree the safety of the walls, but they are a defect that anyone would avoid. In some cases the fault is not due to any weakness of the stone itself, but to the uneven settling of the foundation. A very striking illustration of this can be found in a large and costly modern building in the lower section of New York

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known as the "Swamp." It is a corner building, and on the side street almost every sill and lintel has cracked. In one place a line of fissures extends almost from the foundation to the cornice. Every stone in the window jambs at one side of a line of windows from top to bottom of the building reveals a crack. The structure is not a skyscraper, and the walls are of massive blocks of Indiana limestone, so that their stability is in no degree threatened. The foundations were not carried down to bed-rock, and an uneven settling was undoubtedly caused by some movement of the quicksands that underlie all this portion of New York.

Inasmuch as mention has been made of this matter, it is well to consider whether engineers should not give greater attention to the results likely to follow the modern method of laying foundations. In carrying water-tight walls of all large buildings down to the bed-rock, the movement of underground waters must be seriously disturbed. There are several well-defined streams flowing under the surface of lower New York, and these are frequently checked and turned from their regular course by the caisson-workers. In time many foundations of ordinary depth and strength may be undermined, with great damage to the superstructures.

When the craze for brownstone some years ago led to the erection of block after block of buildings of this strongly laminated sandstone in all of the leading cities, but little study had been made of the economic qualities of stone. If blocks of suitable size and of apparent soundness were delivered, architect and builder asked little more. But in a few years this brownstone began to disintegrate and scale off. Without taking into account all of the causes that gave rise to the weakness, but picking upon one only, the demand became imperative that hereafter this stone when used in masonry should be laid upon its natural bed. Gradually the "natural-bed" idea spread until it was applied to all stones, and became one of the most important clauses in stone specifications. It is no uncommon thing to find a call for stone to be laid on its natural bed when nothing save the most careful and minute examination of each block could determine which was the bedding plane. Even in the brownstone itself, blocks that are exposed on two sides will frequently be seen to have scaled off equally freely on each side, proving that some weakening agency, aside from the tendency to weather on the bedding planes, has been at work. Perhaps this may have been the stunning of the stone in dressing, or the loosening of the cementing material by too heavy charges in blasting.

This insistence upon the "natural bed" in specifications, and in the work of the testing experts, who recognize only "bed" and "edge" in their figures, would create the impression that stone was the one solid that had two dimensions only. Stone-workers who study carefully the nature of the material they handle, designate the three planes of a block of stone according to the ease with which they work. The direction in which a stone splits most easily is the "rift"; the next easiest plane of fracture is the "grain," while that which offers the greatest resistance to splitting is the "head." Paving-block cutters, or sett-makers as they are termed in England, are compelled to give most careful study to these three planes of fracture if they are to do their work rapidly and well. In the paving block as it is set in the street, the two sides represent the rift of the rock; the top and the bottom, the grain, and the two ends the head. In other words, the size of the surfaces is properly apportioned to the relative ease in working along the planes of cleavage. This means that the block is gotten out with the minimum number of blows, and also that the largest surfaces are the smoothest. If one examines the ordinary paving block he will see that the ends are apt to be uneven, especially in a strongly laminated stone like the Medina sandstone. While this stone breaks very freely along the rift, it is inclined to be "plucky" on the head. If an attempt were made to break the long side with the head of the stone, the surface would be so knobby and uneven that the blocks could not be laid with the close joints called for in most street-paving specifications.

There are very few stones, of the nature of liver rock, which seem to have no appreciable rift or grain, but break in any direction with a conchoidal fracture. These, however, are rarely used for structural purposes. The rift is almost always in a plane parallel with the natural bed, and in laminated or thinly-bedded stones the facility with which they split in this direction is what has led to the general call for the laying of stone "on its natural bed" in masonry. In such cases the requirement is right and proper. But where the rift is not coincident with the bedding plane, but may be at a sharp angle with it, or where the stone is quarried and cut without any regard to planes of strength and fracture, some other safeguards to get the full resistance of the stone are necessary.

Roughly speaking, there are two methods of quarrying. In one the stone is broken out by blasting or wedging along the natural lines of cleavage. In the other, by means of channeling machines, blocks are cut out of the mass of rock without dependence upon bedding seams or other natural aids. Beds of stone generally lie at a greater or less angle from the horizontal, but the channeling machine runs upon tracks and it is desirable to preserve a level quarry floor. By means of an undercutter, or by deep holes bored by a gadder, the stone can be taken out in rectangular blocks without considering the rift. For building purposes a block of stone may then be sawed into a thin platform or into a long lintel. When delivered at the building, therefore, the plane of least resistance may be in the line of the smallest dimension. And still the stone would be laid on its "natural bed," for in quarry parlance this means merely that the stone is set in the masonry horizontally as it lay in the earth. To give one of the simplest illustrations: A flagstone is always of necessity quarried with the rift, and in a platform 6 ft. square and 5 ins. thick, the line of easiest fracture, which is along the plane of stratification, is 6 ft. But in a platform of marble or limestone of the same size and quarried in the usual way, if the natural bed, and therefore presumably the rift, was at an angle of 45° (an unusual pitch but taken merely for convenience in figuring), the plane of least resistance would be only 7.0710 + inches. It will thus be seen how little dependence can be placed upon the official figures of the strength of stone, unless every possible factor in relation to quarrying and dressing is taken into account.

As modern building construction goes, where so much depends upon the taste of the owner for a popular material and upon questions of cost and time, it may not always be possible to use the stone best fitted to resist the various stresses of a particular design. But, at least, annoying failures can be avoided by a refusal to base computations upon figures that are misleading because they contemplate conditions not attainable in practice. Still more, if certain stones, like extra long lintels, are called upon to bear a severe strain, the architect can insist that these be quarried by plug and feathering along the rift so as to get the fullest possible strength of the stone. It would mean added trouble, but it might pay well in the end.

RAILWAY-MOTOR-CAR TRAFFIC.*

By Hurry Riches† and Sidney B. Haslan, Assoc. M. Inst. M. E.

The best method of conveying passengers is that which yields the best results on the balance sheet and at the same time gives satisfaction in other ways. Railway-motor-cars for passenger traffic on local and branch lines should be selected with this idea in mind.

According to most locomotive engineers, and many electrical engineers, railway electrification is justifiable only for suburban close traffic. The electrification of branch and main line traffic will, as a general rule, result in a loss to the railway company, since the load factor will be very poor owing to the intermittent traffic. Suburban traffic, however, especially in thickly populated areas, requires more frequent service and a greater acceleration of speed. If the suburban railway system is to hold its own with municipal railway competition it is therefore not only desirable but quite necessary that a frequent service with high acceleration be established in suburban districts. Although several attempts have been made on various lines to meet this competition by the use of self-contained cars, the requirements heretofore were not great enough to warrant a continuance of the experiment.

The Taff Vale Railway Co., Cardiff, England, had a branch line which was not as profitable to work as was desired, and with the idea of getting a better and cheaper method of operation, careful comparisons were made of both capital and running costs of steam and electricity. The electrical methods considered were the following: Self-contained cars, that is, those worked with storage batteries; the third-rail system; the overhead system both with bonded rail return and with new return rail; and the overhead system with lead and return rails. The results obtained are given in the table at the foot of this page.

The conclusion drawn from the figures secured was that steam gave a better and more economical service than electricity unless trains were run under a few minutes' headway and the distance from the power house was comparatively short. As to taking current from a supply company in preference to installing a generating plant, it was concluded that where considerable variations of load are common and the undertaking not large, the supply company can generate the current much cheaper. If, however, the length of line to be electrified is great, current could be generated and supplied at several points along the line, thus reducing the line losses and the increased outlay.

TREE-GROWING BY RAILWAYS has been taken up actively of late on account of the increasing difficulty in obtaining sufficient timber for railroad ties at a reasonable price. The Atchison, Topeka & Santa Fe R. R. has purchased 8,659 acres in California and will plant trees on about 600 acres of this land each year. Eucalyptus trees have been chosen on account of their rapid growth; it is estimated that at the end of 20 yrs. each of these trees will provide six or eight ties.

*Abstract of a paper read at the Cardiff meeting, 1906, of the Institution of Mechanical Engineers.

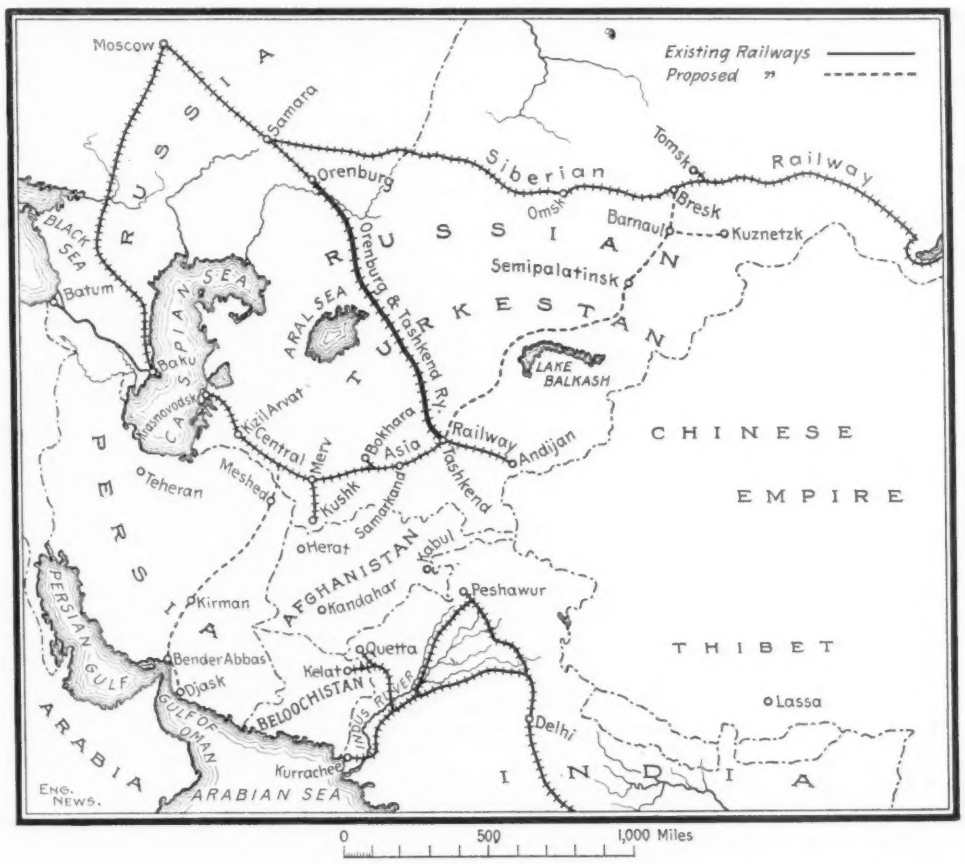
†Vice-President of the Institution of Mechanical Engineers and associated with the Taff Vale Railway, Cardiff, England.

TABLE OF COMPARATIVE COSTS OF RAILWAY MOTOR CARS.

Details.	Cost of original system, small engine and train.	Storage Battery—Own power supply.	Storage Battery—From supply company.	Third-rail system from supply company.	Steam cars.
Single car.					
Capital cost.....	½ engine, per day, $3,665 Carriages, 8,875	Car complete, $20,000 Generating Station,..... 5,750	Car,.....$20,000 Trans-formers, 500	Car,.....$6,750 Six miles of rails,..35,680	Car, $10,500
	$12,540	$25,750	$20,500	$42,430	
Interest at 4%....	$500	$1,030	$820	$1,695	$420
Maintenance, wages, etc.	4,875	3,580	2,710	3,400	1,255
Total.....	$5,375	$4,610	$3,530	$5,095	$1,675
Giving at 11,000 miles per year a cost per mile of	$0.23	$0.20	$0.15	$0.22	$0.08
Two cars. Cost per mile...	.....	$0.20	$0.15	$0.16	.....
Three cars. Cost per mile...	.....	$0.19	$0.15	$0.14	.....

RAILWAYS IN CENTRAL ASIA.

About twenty-five years ago the Russian Government began the construction of a railway line eastward from the Caspian Sea through Central Asia (or Russian Turkestan); this railway has gradually been extended as far as Tashkend, and has now a length of over 1,500 miles. In the past few years another railway has been built from Orenburg, on the frontier of European Russia, to Tashkend, thus putting the older line and the heart of this little-known region in direct communication with the Russian railway system. These railways were built mainly for military purposes, but have already developed an important commercial traffic; a purely military line has been built as a branch from Merv south to Kushk, on the border of Afghanistan, and a railway for both military and commercial purposes is projected through Persia to a port on the Persian Gulf. A very important extension is now projected, running from Tashkend northeast to the Siberian Railway; this would be at first mainly a military line, but would develop a territory which is said to be rich in agricultural and mineral possibilities. The accompanying map shows these several existing and projected railways, and also shows their position relative to the Indian Railway system along the northern boundary of India. The following particulars are taken from an article in "The Engineer" (London):



MAP OF RAILWAYS IN CENTRAL ASIA.

During Gen. Skobeleff's campaign against the Tekke Turcomans in 1880-1881 there was built, for military reasons, the Trans-Caspian Railway, from Mikhailovsk, on St. Michael's Bay, on the Caspian Sea, and opposite Baku, in a southeasterly direction to Kizil Arvat, a distance of 210 miles. Gen. Annenkoff was in charge of the difficult task of laying down a railway across the sandy desert. Between 1885 and 1887 the railway was carried to Askhabad, near the Persian frontier, and thence to Merv and Charchui, on the left bank of the Amu Daria. The choice of Mikhailovsk proved to have been unfortunate, as the waters of the Caspian Sea at that point are not deep enough to allow steamers to land. A new starting point and harbor were made near Usun-Ada, about eight miles to the northwest. This harbor was used until 1896, when it was found that the water could be kept at sufficient depth only by costly dredging. A new starting point was then made at Krasnovodsk, still further to the northwest, and a well-equipped harbor was established there. This new section of the line was opened in 1896.

In 1887 the Trans-Caspian Railway was carried across the Amu Daria and east to Samarkand, a distance of 943½ miles. In 1897-98, Russia built a branch line south from Merv to Kushk on the northwest frontier of Afghanistan. All these railways were built and managed by the Ministry of War, but in January, 1899, the railway system was called the Central Asian Railway and placed under the care of the Ministry of Ways of Communication, which has laid down the extension of the railway from Samarkand to Tashkend and the three branches to Andijan, Bokhara and Marghilan. The following table shows the description of this railway system, as at present completed:

	Length miles.	Stations.	Distance between stations. Ave. miles.	Max. miles.
Krasnovodsk to Tashkend	1,165	60	19¼	44
Branch lines.				
Mery-Kushk	196	9	24½	31⅛
Chernayevo-Andijan	204	15	14⅞	21⅛
Kagan-Bokhara	8⅛	2	8⅛	..
Gortchakovo-New Marghilan	6⅝	2	6⅝	..

The Central Asian Railway is a single-track line with a gage of 5.03 ft., but enough land was acquired for a second track. All the rails were made in European Russia. For the branch from Merv to Kushk light steel rails weighing only 53½ lbs. per yd. were used; the rails used on the other lines weigh from 64 lbs. to 66 lbs. per yd. Neither the grades nor curves caused any great difficulty; the steepest grade is near Kizil Arvat, and is 1 in 53; otherwise the grades do not as a rule exceed 1 in 90, while curves below 1,200 ft. radius do not occur. The width of the embankments is from 10 ft. 8 ins. to 16 ft. 8 ins., and the cuts are 10 ft. or 15 ft. 8 ins. wide. The stations are one-storied buildings; timber has been used in the regions liable to earthquakes, and in some cases brick or rubble has been used; in the sandy desert region the buildings are of timber.

The question of fuel has been a serious one, but the discovery of petroleum helped to solve the difficulty. On the western section of the line a supply of petroleum is obtained near Balla-Yshem, while on the eastern section the oil fuel is supplied by the oil wells in the Ferghana Territory. The coal used on the railway is supplied by the coal mines in the province of Samarkand. In 1901 the coal used amounted to 1097 tons, while that of oil refuse was 89,763 tons. In 1903 the rolling stock consisted of 396 locomotives, 765 passenger cars and 14,400 freight cars. Up to the end of 1901 the total outlay on building the railway was $59,044,875, or $39,460 per mile.

As the Central Asian Railway was intended above all things for military purposes, its equipment and buildings were of the simplest character. The buildings were put up with the smallest possible outlay; most of the bridges were built of wood; for long distances the ties were laid down on an unballasted bed, and freight cars were used as passenger coaches. The authorities did not encourage passenger traffic for obvious reasons. Two mail trains traveled in either direction twice a week in winter and thrice a week in summer, while only one mixed passenger and goods train traveled daily. However, as the adjacent territory was colonized the railway was improved. Thus, plantations of the saxaul, an indigenous shrub, protected both sides of the line from the frequent disastrous effects of the winds and sandstorms; the slopes of the cuts were leveled, the ties were relaid on ballast, the rolling stock was enlarged, cars built after European models were brought into use, and the wooden bridges over the Tejala, between Askhabad and Merv, and the Amu Daria, near Charchui, were replaced by iron bridges. The latter bridge deserves mention, as it is the biggest piece of bridge-building carried out by Russian engineers. Inclusive of the approaches, the bridge is 5,667 ft. in length, and it has 25 river spans of 213 ft. 9 ins.

With the extension of the railway to Tashkend and to Andijan, and as the result of its being connected lately with the Orenburg and Tashkend Railway, the passenger and freight traffic has increased, and the trade of Russian Turkestan has been developed considerably. From 1885 to 1887 the railway was worked at a loss; the first returns to show a clear profit on the working were those of 1888. The line was thrown open to regular passenger and goods traffic only on the completion of the Samarkand section in 1889. The passengers carried in 1889 amounted in round numbers to 200,000, and in 1900, after the opening of the Andijan section, to 746,336 persons. In 1900 the gross and net earnings were $5,908,860 and $1,948,575, respectively.

With the opening of the Orenburg and Tashkend Railway, which is 1,140½ miles in length, the great loss of time and the expense involved in conveying troops from European Russia by steamer across the Caspian Sea will be avoided, and troops can be carried to the Persian or Afghanistan frontiers in five or six days. How greatly the new line will assist in developing the local trade in both directions may be judged from the fact that in 1898 about 70% of the freight traffic of the line was through freight, which had to be unloaded for transit across the Caspian Sea and then loaded up again for transport by rail.

After this brief review of Russia's railway construction eastwards of the Caspian Sea, it is opportune to glance at certain other projected railways. The first of these is ostensibly in the interests of Russo-Persian trade. In spite of the absence of railways and good roads in Persia, there is a goodly interchange of trade between both countries by way of Meshed, and for years Russia has been trying to obtain from Persia a concession for building a railway to connect Meshed with a station on the Central Asian Railway, a distance of 167 miles, of which 150 miles would be across a level country, while the rest would run through a hilly district. The line has been surveyed by Russian engineers, who estimate that the cost of construction would be $28,350 per mile across the plain, and $70,875 per mile through the hilly region. There is also a project for extending the railway from Meshed southwards to Kirman, and thence to Bender Abbas, at the mouth of the Persian Gulf, or even to Djask, on the Gulf of Oman.

Another recent project, much nearer accomplishment and of far greater practical utility to Russian Central Asia, is that of extending the Central Asian Railway northeast from Tashkend to skirt the eastern end of Lake Balkash, and, taking in Semipalatinsk and Barnaul, to join the West Siberian section of the Siberian Railway at Bersk. From Barnaul a branch line is to be laid east to the coal fields of Kuznetzk. Hitherto this coal has not been available for use as fuel on the Siberian Railway, owing to the lack of transport facilities. The projected line would be able to carry to Turkestan the cereals produced in the fruitful steppe region, and then large tracts of land at present used for growing corn in Turkestan would be set free for developing the cultivation of cotton. It would have a plentiful supply of coal fuel within easy distance at Kuznetzk. This line would possess also no small military importance.

THE HUDSON BAY ROUTE for grain shipments to Europe is exciting much interest in the provinces of Alberta and Saskatchewan, Canada. The Canadian Northern Ry. has already graded 90 miles of the proposed line (Eng. News, April 5, 1906, p. 372) from Prince Albert, at present the most northerly railway point in Canada, to Port Churchill on Hudson Bay, and next year will complete 200 miles more of the line. It is claimed that Hudson Bay can generally be navigated from July until Christmas.

A NEW AMERICAN GOLD DREDGE.

Gold dredges were introduced into the United States on a commercial scale in 1895. A small electrically-operated dredge was installed that year on Grasshopper Creek at Bannack, Mont. This dredge was designed by Mr. A. W. Robinson, M. Am. Soc. C. E., and was the precurser of several others in that locality, all of which did well and made money for their owners. These early dredges were a combination of a dredging apparatus and a hydraulic sluice-box, and both these elements retained their respective original forms.

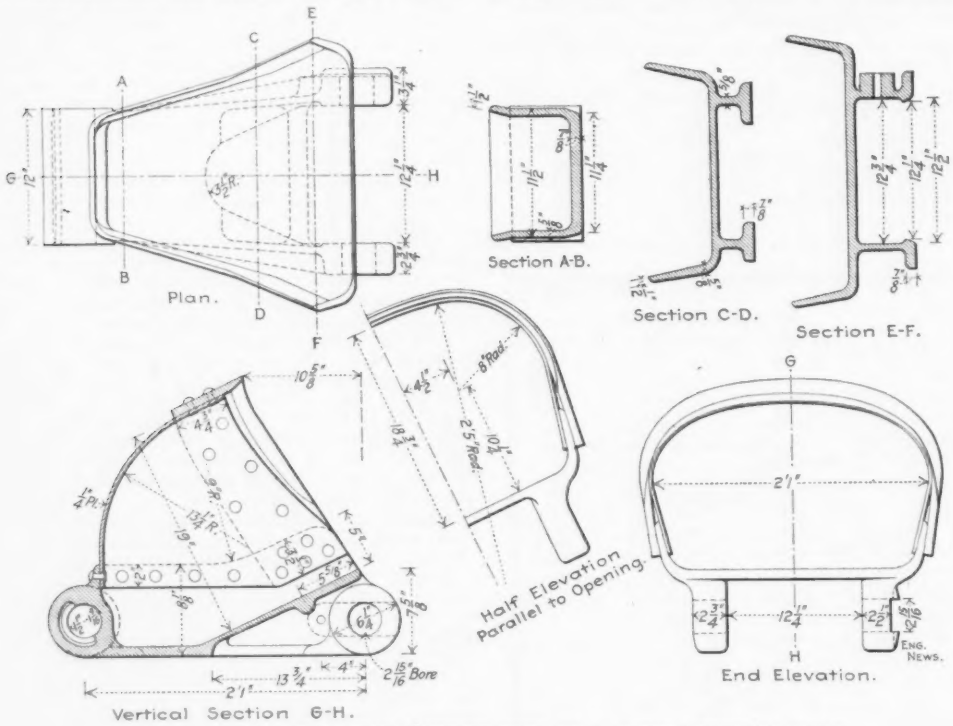


FIG. 1. DETAILS OF THE BUCKET USED IN A NEW AMERICAN GOLD DREDGE OF THE ELEVATOR TYPE.

The dredge designed at that time by Mr. Robinson was of the same pattern as those which have since been used by him for river and channel dredging, and the sluice-box was similar to that long used by miners in hydraulic mining.

The elevator type of dredge was soon recognized as the most successful one for gold dredging. Many experiments have been made with other types, but with poor success. The New Zealand type of dredge subsequently introduced, differed from the American type in having mooring lines instead of spuds, and in place of a sluice-box a fine screen and tables covered with fine riffles or fiber was used for saving the gold. These dredges proved too light for American service, and were too cheaply built. Later, however, both American and New Zealand dredges were strengthened and improved by their respective makers, but the greater size and width of the various parts have greatly increased their cost.

The durability and cost of repairs of the average dredge are still unsatisfactory. According to the report of the state mineralogist of California for 1905, the cost of repairs frequently amounts to 50% of the whole operating cost. In a typical example where three dredges were working together, the average operating cost per cubic yard for the three during one year was as follows:

Dredge crew, power and operating supplies	$2.52
Repairs, labor	.48
" supplies	2.58
Superintendence	.16
General expense	.15
Taxes and insurance	.24

In the Robinson gold dredge, which is now being placed on the market by the Atlantic Equipment Co., 111 Broadway, New York, the aim has been to produce the very simplest construction of working parts that will accomplish the desired result, and to maintain a large margin of strength as well as durability. Effort has been made to retain all the best features of both New Zealand and American practice, and to reduce complications and weight as far as possible by correct design and the use of high-grade steels with as little cast-iron as possible. The result is claimed to be a dredge that is light, strong, easily handled, economical to transport and erect, and that can be depended on to do its work continuously and with light repairs. This dredge is said to have made the remarkable run of 76% actual working time during her trial period of 30 days. The total delays thus amounted to 24% of the time, and included all the time lost in adjusting the new machinery and correcting small defects, so it is expected that in regular work much better time will be made.

The Robinson dredge, of which detail parts are shown in Figs. 1 and 2, is the property of the Gold Bond Dredging Co., J. B. Austin, President, Ransom's Bridge, N. C. It is at work in an alluvial flat forming the bottom of a low valley and through which runs a small brook which would readily pass through an 8-in. pipe, and which keeps the pond supplied. The ground is covered with heavy pine timber which, when cut, yields fuel for the dredge, and the stumps are readily dug out by the dredge itself. Gold is found in good paying quantities and is of varying degrees of fineness.

The hull of this dredge is of wood 94 ft. × 32 ft. × 7 ft. It is very strongly built and the well sides are carried aft the whole length of the boat to form bulkheads. There are also steel hog-rods forming two fore and aft trusses. The ladder frame is of steel and long enough to dredge in 30 ft. of water. The buckets, Fig. 1, have a capacity of about 3 cu. ft. each. The back of the bucket is of cast steel, the pins are 3 ins. diam. of steel, and the bushings are of manganese steel 12 ins. long. These bushings are specially made to slip in or out of recesses shaped to a half circle so as to be readily renewed. The shaft of the lower tumbler is of hammered steel and runs in enclosed bearings in the end of the ladder frame; these bearings also have renewable bushings. The upper tumbler, Fig. 2, is of cast-steel, and has five sides; it is fitted with driving faces by means of which the driving power of the tumbler is applied directly under the center of the bucket-pins. The buckets run smoothly at a speed of 24 ft. per min. This is equal to buckets of 6 cu. ft. capacity of the open-connected type running at 12 ft. per min. The buckets discharge through a steel hopper into the revolving screen which is 4 ft. 6 ins. in diam. × 16 ft. long. This screen is made with interchangeable perforated plates on a steel frame, so that the plates can be renewed or replaced without taking down the screen.

The head frame and driving gear for the buckets and screen are very strong and simple in construction, there being but two working shafts and four bearings in the entire machinery, including tumbler drive and screen drive. These two shafts are the upper tumbler shaft and secondary or pinion shaft. The main gearing is of steel, and a steel-rimmed pulley of large diameter on the end of the pinion shaft is directly belted to the main engines on deck. The revolving screen is driven from the secondary shaft which passes directly above it. On the screen is a cast-steel spur gear of 2-in. pitch and 6-in. face, which also has a flange or roller-path attached to it. The screen is mounted on adjustable steel rollers running in dirt-protected bearings. An adjustable friction clutch is provided at the main pinion, which will slip in case of sudden strain, but the belt transmission also provides safety in this respect.

The main engines are of 50-HP. and of the vertical marine type. In this case they are double cylinder high pressure for the sake of simplicity, as wood fuel costs only the labor of cutting it—about $1.00 per cord. For situations where greater economy of steam is important these engines can, of course, be made compound condensing. The main engines are handled entirely by the operator on the upper deck. Here he has a full view of his work and can see the buckets for their whole length, and the tailings conveyor as well.

The winch is on main deck directly under the operator, so that the levers for its various motions can be conveniently placed. It has six drums each with independent friction clutch and brake, as follows: One head line, one ladder hoist, two forward side-lines and two after side-lines. By means of these steel wire rope lines, the position and feed of the dredge are under perfect control.

The water supply for the screen and tables is furnished by an independent centrifugal pump with 10-in. discharge, driven by a direct-connected engine.

Steam is furnished by one boiler of the Worthington watertube type of 125 HP. Inferior wood can be burned as the fire-box is large and roomy, and covers the entire bottom area of the boiler. The boiler has a steam and water drum of sufficiently large dimensions to avoid sudden fluctuations of pressure and water-level, and has proved very satisfactory in service. The consumption of green pine wood will run from 2 to 2½ cords per shift of 12 hrs. steady working. Assuming the actual output of the dredge to be 1,000 cu. yds. per shift of 12 hrs. (which is half its theoretical rate and is a low average in practice) and there be required 2½ cords of wood at $1.00 per cord, we have a fuel cost of one-quarter of a cent per cubic yard of material handled.

The gold-saving tables are arranged on both sides of the after deck under a distributing-box of special design, by means of which the wash from the entire length of screen is mixed and distributed uniformly to the tables.

To save a high percentage of gold requires first, thorough washing of the gravel; second, proper concentration; third, thorough mixing and even distribution of the concentrates over the tables, and fourth, a riffled surface on the tables that in area, slope and type of riffle is well adapted to the particular material to be dealt with. A correct understanding of the principles of gold-washing is necessary as well as a correct "diagnosis" of the local conditions to be met. What will suit one locality may be a failure in another.

The system of tables adopted in this dredge is a flexible one that can be adapted to any material and hold any kind of riffle. There are 28 tables each 1½ ft. × 8 ft., which give a total surface of 336 sq. ft. In addition there are 94 sq. ft. of riffles in the distributing and tailings sluices, or a total of 430 sq. ft. of riffle surface. To carry off the coarse tailings a stacker or tailings conveyor 70 ft. long is employed. This is of the rubber-belt type driven by an independent engine. The belt is 30 ins. wide, and the end of the conveyor is 25 ft.

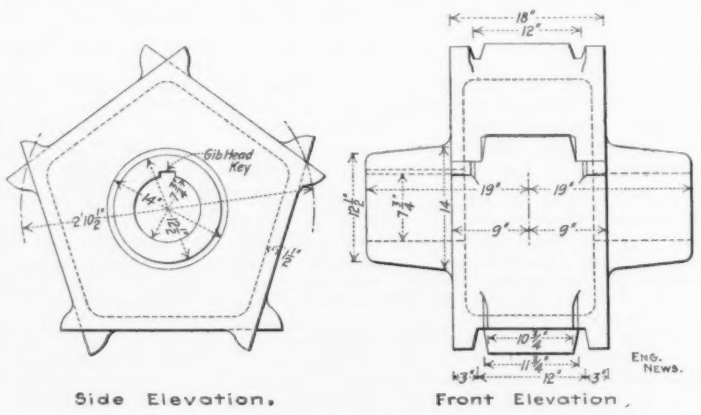


FIG. 2. THE UPPER TUMBLER OF THE GOLD DREDGE.

above the water level. In operation, the wear is confined to renewable parts such as pins and bushings, dipper lips, screen plates, etc. The load of all the parts is so balanced on the hull that it sets level at a uniform draft of 3 ft.

The increasing use of the dredge for working low-lying and low-grade alluvial ground has opened up a wide field for this class of mining. Formerly ground that would not pay over 25 cts. a cubic yard was not considered profitable, and this is probably still true in the far north and in localities where freight, fuel and labor are expensive, but under ordinary conditions, ground which was formerly thought worthless can now be worked at a profit. With proper business prudence and thorough prospecting, gold dredging becomes one of the safest kinds of mining. With a correct knowledge of the ground and its contents, it becomes a manufacturing proposition with all the proverbial uncertainties of mining eliminated.

RESULTS OF OPERATION OF TWO SMALL PRODUCER GAS ENGINE PLANTS.*

By Paul Winsor.†

This paper will deal with the experience that the Boston Elevated Railway Company has had with its two gas-engine plants, at Somerville and Medford. These plants have now been in operation, one about four months, and the other (partially) for a few weeks.

A little over a year ago the subject came up of supplying power to two sections of the railway that were rather hard to reach from the present power stations, and as we had for some time been looking into the question of gas engine, it was decided that this was a good opportunity to make a trial of them. Both plants are small, one of 700 KW., the other of 975 KW. The engine load-factor in both stations can be made extremely good, as they feed into the trolley lines in multiple with the steam stations of the road.

The equipments of the two plants are radically different. The Somerville plant has downdraft suction producers and four-cycle single-acting engines, while the Medford plant has updraft pressure producers and two-cycle double-acting engines.

Unfortunately for this paper, we have run the Medford station so little—through no fault of the equipment contractors—that no figures are available, and I must, therefore, confine most of my remarks to the Somerville station.

MEDFORD STATION.—This station has R. D. Wood gas producers, with blowers, tar extractors, scrubbers, etc.; Koerting two-cycle double-acting gas engines; and Crocker-Wheeler direct-current generators. The gas plant is similar to, although larger than, the United States Government testing plant at St. Louis, which has been in continuous operation now for two years of more, making gas successfully from all kinds of coal. The engine plant is similar to, although smaller than, the Lackawanna Steel Company's plant at Buffalo, where they have a large number of these engines running successfully on blast-furnace gas.

As before stated, this plant has been run very little. This has not been the fault of the plant, but has been owing to our wishing to thoroughly work out the exhaust question before putting the plant into regular operation. The station is in a residential district, and the noise of the exhaust of the one engine started was such as to seriously annoy the neighbors. We have, therefore, been experimenting for nearly two months, during which time only one engine has been run, and that very little, so that no economy tests have been possible.

SOMERVILLE STATION.—A Loomis-Pettibone gas plant, with the necessary exhauster, scrubbers, holders, etc.; American-Crossley engines, and Crocker-Wheeler direct-current generators.

The Somerville station has been in commercial operation since May 4, 1906, and up to Aug. 31 it has used 1.45 lbs. coal per kilowatt-hour.

During May—from May 4 to May 29, inclusive—but one engine was in use. Since then two engines have been running. The station is run week days from 7 a. m. to 11 p. m., and on Sundays in the afternoon only. The engine load-factor has been about 74%.

On June 10 a thirty days' test run was begun. During these thirty days the station was run sixteen hours per day, from 7 a. m. to 11 p. m., with an engine load-factor of a little over 70%. The average (Pocahontas) coal per kilowatt-hour delivered from the station was 1.31 lbs. This included all the fuel used, whether for running the engines, building fires after cleaning, or in the auxiliary boiler.

As already stated, during the four months in which the station has been in regular commercial operation the fuel per kilowatt-hour of output has been 1.45 lbs. These figures are as good as the most enthusiastic have ever hoped for. The plant has proven its reliability, and the shut-downs have been very few. There have been no shut-downs of any kind in the gas house. This portion of the plant has run regularly and without any trouble and has made a uniform grade of good gas.

In the engine-room there have been interruptions, but these have almost all been of the kind to which any new power plant is subject. The longest delays, in fact the only real shut-downs, were due to improper water connection with the piston. This matter however, has been remedied. We have had one case of hot crank-pin, probably due to too quick starting. These engines can be set running so quickly—well inside of sixty seconds, and often close to thirty seconds—that the temptation has been to see how quickly it could be done, resulting, as before stated, in one case of hot crank-pin, the oil not having been given time to reach it after six hours' shut-down.

As a result of my experience with these plants, I am absolutely convinced of the economy and reliability of a gas-engine power station. The fuel consumption will be about one-half as compared with a steam plant, running from less than 1.5 lbs. to 1.75 lbs. per KW.-hr., according to the load factor and almost regardless of the size of the plant, as against 3 to 4 lbs. in similar steam plants.

The cost of the gas plant, including producers, is undoubtedly considerably higher than the cost of a similar sized steam plant, and whether the fuel saved will justify the increased capital depends on the price of coal, but it seems that with coal at $3 and upwards there will be a material net saving by the use of gas. Another advantage of a gas plant is the high efficiency of a small plant, the efficiency being practically the same for engines as small as a couple of hundred horse-power as for those of larger size, which of course is not true of a steam plant.

The question is of course asked: "What are the disadvantages of a gas power station as compared with a steam plant?" I am glad to say that they are few. The gas-producing portion of such a station is simpler, easier to operate, and holds its efficiency better than a steam plant. The losses from banking fires are extremely small, and the plant can be gotten into service much quicker than can a steam plant. It is our practice to shut down at 11 at night and start at 7 in the morning. Fifteen or twenty minutes are required to get the gas plant into full operation, while of course with a boiler plant it takes from 1 to 1½ hrs. to get the fires into first-class shape. The ashes have to be periodically removed from the producer. In our plant this has to be done while the producers are out of commission and takes about three hours twice a week, although the plant can be run a couple of days longer without cleaning, if necessary. With some forms of producers the cleaning can be done while the plant is in operation, but I have had no experience on this point as yet, as our second plant, which has this form of producer, has not been in continuous operation. The wet and dry scrubbers have to be cleaned every few weeks, but this work is certainly no more difficult than the work required around a boiler, cleaning soot from the tubes and from the soot-chambers.

An ordinary gas man, such a man as would be considered a first-class fireman, can run at least as many horse-power of gas-producers as he can of boilers. He can make a very uniform grade of gas and will get regularly very much nearer the possible efficiency from the gas-producers than from the boilers. We have, however, found the Ados CO_2 recorder of great assistance. Without it we find that the gas man would vary his CO_2 from 5 to 7%, while with it he would hold it below 5%. It is, of course, much more satisfactory for a man to know actually what he is doing from minute to minute than to work entirely on his judgment.

The ordinary steam engineer is, of course, afraid of a gas engine, just as a stationary engineer is afraid of a locomotive, but a few months' practice should make of a good steam engine runner an equally good gas engine runner.

The handling of the water jackets is extremely simple. The problem comes in the ignition, but with a well-designed gas engine, equipped with a duplicate system of igniters, there would be little, if any, trouble.

A gas engine will hold its efficiency much better than a steam engine. With a steam engine, poorly-set or leaky valves will interfer seriously with its efficiency. With a gas engine the effect of improper ignition or valve setting, or even leaky valves, is generally either to cause a knock, therefore at once announcing itself, or to reduce the output of the engine. None of these things materially affect the efficiency without showing also in other ways.

The water required is considerably less for a gas plant than for a condensing steam plant and considerably more than for a non-condensing steam plant. A non-condensing steam plant will use for all purposes from 40 to 50 lbs. of water per KW.-hr. A condensing steam plant will use from 20 to 30 lbs. for steam, and from 600 to 900 lbs. in the condenser per KW.-hr. A gas plant will use about 200 lbs. per KW.-hr.

The only two serious troubles that we have had have been premature explosion and back-firing in the engines and noisy exhaust. The exhausts we now have pretty well under control and certainly they can be made entirely unobjectionable, if not noiseless. Premature ignition and back-firing have both given us a good deal of trouble, and on both types of engines have at times been bad, so bad as to materially reduce the engine power for the moment. This trouble is now much less than it was, and even if not further eliminated will not interfere with the regular and commercial operation of the plants.

There are many forms of producers than can be used successfully with hard coal, using sizes at least as small as pea and as small at No. 1 buckwheat if it is of good quality. Soft coal cannot be used in most of the producers without the addition of tar extractors. Much soft coal has been used at the Government Testing Station at St. Louis, the tar extractors doing their work very successfully. Soft coal can be used in down-draft producers, such as we have in our Somerville Plant, without any tar getting into the gas, the tar being "cracked" on passing through the hot fires, breaking up into gas and some lamp-black, this lamp-black dirtying the scrubber water to such an extent as to make it objectionable if turned into a clear stream. This lamp-black can, however, easily be separated from the water by allowing the water to become quiescent in a comparatively small tank, the lamp-black rising to the surface.

For many years and up to very recently, gas engines have been made by comparatively small companies and in small sizes, most of them following closely the early gas engines in being single-acting and having trunk pistons. This form is not adapted to large sizes, it being expensive, if not impossible, to build, and requiring a great deal of oil. Most of the engines have been and are being built on the four-cycle principle, there being, so far as I know, but one large manufacturer of two-cycle engines. In the last couple of years the large steam engine manufacturers, such as the Allis-Chalmers Company, the Snow Steam Pump Company and the Westinghouse Machine Company, have been making large gas engines, and there have been a considerable number of engines from 2,000-HP. and upward run during the past year, so that to-day there is no trouble in purchasing engines of standard design in the large sizes. All three of these companies have adapted the successful designs of steam engines to the gas engines, using disc-cranks and double-acting cylinders, generally two cylinders in tandem, giving two impulses to each revolution of the crank, as with the single-cylinder steam engine. In the larger sizes they use the two-crank arrangement with the generator or fly-wheel between, each crank having two double-acting cylinders. The valves are always poppet valves, both intake and exhaust driven from a lay shaft parallel with the cylinder.

As this problem has been taken up independently by these three large and successful steam engine builders, and all have arrived at practically the same solution, it is safe to say that the gas engine of the immediate future will be of this type.

*Abstract of a paper, entitled "Gas Engines," read before the American Street & Interurban Railway Engineering Association at Columbus, Ohio, Oct. 15 to 19, 1906.

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PLATINUM is the subject of an unusually interesting advance chapter from Mineral Resources of the United States for 1905 (U. S. Geological Survey, Washington, D. C.), by Mr. F. W. Horton. The price of ingot platinum per ounce increased from $18.50 in December, 1904, to $34 in September, 1906. The prices of manufactured platinum in various forms on Dec. 31, 1905, are given by Mr. Horton as follows:

Heavy sheet and rod, 75 cts. per gram, or $23.33 per oz.
Foil and ordinary sizes of wire, 80 cts. per gram, or $24.88 per oz.
Crucibles and dishes, 85 cts. per gram, or $26.44 per oz.
Perforated ware and special sizes of wire, 90 cts. per gram, or $27.99 per oz.
Cones, $1 per gram, or $31.10 per oz.
Gas-engine sparking points, from 87 cts. for A to $1.80 for B.

In March, 1906, quotations for the same forms of platinum were about 20% higher. The most promising fields for the production of platinum in the United States are southern Oregon and northern California, but in addition it is found in a number of other Western States and in Alaska, besides which "isolated occurrences of single nuggets or mere traces of the metal have been found" in a few Eastern States. The total production of platinum in the United States in 1905 is reported as 318 oz., valued at $5,320, as compared with 200 oz. valued at $4,160 in 1904. The imports of platinum in the United States during 1905 were valued at $2,173,263, and in 1904 at $1,879,155; 1903, $2,055,933; 1902, $1,987,980; 1901, $1,695,895. It will be understood, of course, that these figures include both nuggets and manufactured products in various forms.

THE TREATMENT AND DISPOSAL OF SEWAGE.*

By John D. Watson,† M. Inst. C. E.

The question of sewage disposal is gradually but surely assuming a more definite position in municipal engineering as knowledge and experience progress, dogmatic assertion and unreasonable bias recede, with the result that engineering works pertaining to sewage disposal are now being designed on lines that will prove to be more permanent than anything we have seen hitherto.

It was fashionable a few years ago to speak disparagingly of sewage farms, as if they were wholly bad. Bacterial treatment was spoken of as something entirely different from land treatment, the septic tank process was lauded to the skies as a modern invention that was capable of getting rid of organic sludge without human effort, the use of chemicals for precipitating the solids in sludge was regarded as an ancient method unworthy of consideration in designing modern plant. Now we are in a position to regard the discoveries of the past ten years in truer colors and more accurate proportions. The much maligned sewage farm may still (where the conditions are favorable) be allowed to rank as one of the best methods of sewage disposal. Diverse opinions may be held as to what are favorable conditions, particularly as conditions are sure to vary widely with locality, but it may be assumed that where there is one acre of suitable land available for irrigation, and not more sewage than is represented by a population of 100 or 150 to be treated upon it, as in Berlin and several other important cities, the efficiently-worked sewage farm, when judged solely by the standard of the effluent produced, is still in the foremost rank. Effluents from such a farm are remarkable for their paucity of micro-organisms, low albuminoid ammonia, and what at first sight might appear to be a less desirable quality, low nitric nitrogen, and last, but not least, the steady, unvarying character of the land effluent. These are advantages which more or less obtain over what may be termed the modern, more hygienic, more economical, and perhaps in other respects better method of purification advocated under the name of biological or bacterial treatment.

The sewage disposal problem varies with every town and every district, and the overlooking of this fact has led not only local authorities, but also their advisers, to make mistakes. In this populous country of ours one ought not to forget that in the vicinity of towns land suitable for irrigation is very difficult to obtain. The area necessary for efficient treatment is rarely available, and even where it has been at one time available the increasing population, and the consequent increase in volume of sewage, often outgrows the ratio between volume and land which must be maintained to command efficiency. This is what has happened in the Birmingham district, where various towns, having Birmingham as the predominant partner, have combined to form a joint board, which has jurisdiction over an area of about 100 square miles and a population of about 900,000 people. This large population increases so rapidly that the existing irrigation farm, which occupies nearly six miles of the valley of the Tame, would have to be increased by nearly two acres per week if it were essential that the sewage should continue to be treated by irrigation. Fortunately, it is not essential that this great farm should be indefinitely extended, otherwise the unwilling seller would require the still more unwilling buyer to pay a ransom for land more or less unsuitable for his purpose.

It is obvious that this is a case where land treatment of sewage, from the point of view of area alone, is an increasing difficulty, devoid of the only feature that would justify it—finality.

Theoretically, a sewage farm may be ideal, but it is difficult, if not impossible, to obtain the ideal in an immense sewage farm. I do not suggest that anything in the nature of a nuisance need arise, or that the general conditions pertaining to such a farm need give rise to sickness or disease, but it is needless for advocates of sewage farming to deny that in some states of the atmosphere a certain amount of smell in the vicinity of land saturated with sewage is unavoidable; indeed, all sewage purification works should be controlled under the impression that they are liable to give rise to nuisance, and that it is essential to adopt every reasonable precaution against mishap. With that in view, an oxidation process that will fulfill the functions of oxidation and nitrification with the least surface area exposed to the atmosphere is (all other conditions being equal) the process that should be adopted in the interests of the general public. Judged by this standard, a percolating bed is double the value of a contact bed, and more than fifty times the value of land.

Although I do not propose at this time to deal with the question of arresting and disposing of the solids contained in sewage, I regard that process as the most important work of sewage purification, and, as I stated in a paper read before the Association of Municipal and County Engineers in London two months ago, any scheme that gives sludge disposal a second place is based on a wrong conception of efficient treatment. Whether the removal of the grosser solids should be effected by the construction and erection of tanks and machinery, together or separately, aided or unaided by chemicals, is a question that must be determined by special circumstances belonging to each case.

OXIDATION AND NITRIFICATION OF SEPTIC TANK LIQUOR.

This may, as I have already indicated, be done efficiently in more ways than one, but I propose to confine what I have to say to the process in its relation to bacteria beds, and particularly to that class of bed known as the percolating bed, the most extensive example of which is to be seen at Birmingham.

When the site is acceptable a percolation bed is undoubtedly the best form of bacteria bed, and it should be constructed substantially of good material throughout. The floor should be of cement concrete, or, if the work may be done leisurely, lime concrete, floated to a smooth surface. Upon this impervious floor some engineers proceed to lay medium to form a habitat for the bacteria, and where a low initial cost is a matter of prime importance they may be justified, but where good permanent work is wanted a false floor of semi-circular tiles laid on the concrete floor should be employed. Unless an open or aerating floor is used the sewage effluent, and particularly the solids contained therein, emerges from the bed with difficulty, if at all. The suspended matter gradually chokes up the bottom of the bed, thus reducing the depth of medium available for purification, as well as excluding all chance of aeration for the lower portion of the bed.

The aerating floor was first used by Mr. Corbett at Salford. Its form, and particularly its cost, were, however, a great drawback to its general use. This led me to inquire of several stoneware goods manufacturers about their prices for half-pipes. The result was the tile patented by Messrs. Bryan & Mansfield, and it is, I believe, the best and cheapest. Other good tiles may be had, but, so far as I know, there is no other that can be laid on the floor ready to receive media for less than 2s. 6d. (60 cts.) per sq. yd.

By using an aerating tile the effluent, after percolating through the bed—a period that usually occupies from three to four minutes—quietly flows along the impervious floor towards the effluent channel, which may or may not be placed in the middle of the bed, but which is invariably placed at a lower level. Should the effluent contain solids in suspension, those solids are frequently deposited on the concrete floor until they have accumulated sufficiently to stem the flow of water. When this stage is reached the water exerts its power of removing particles and sometimes masses of the suspended matter, and should it be necessary it is easy to flush the obstruction right away.

The aerating tile is large enough to maintain sufficient space for aeration under all conditions. This is an important feature, as there is a distinct tendency for carbonic acid gas to accumulate in the bottom layers of the bed. The provision of a false floor and air space between the medium and the concrete floor is also necessary for mechanical reasons, for it is obvious that suspended solids cannot force their way through a bed in a lateral direction, and that if they exist in a bed the best thing is to help them to get free of the medium, where their lodgment can only do harm. This leads to a question which perhaps should be dealt with later—do percolating beds choke? After from four to six weeks' continuous work a bed shows signs of water-logging due to the accumulation of a viscid substance on the surface. This matter can be removed by loosening the surface layer either by forking or by resting and drying. On restarting, large quantities of suspended matters are washed through the bed, especially when the bed is purposely flushed out. The cost of the flushing operation is trifling, and after it the bed is left in a better state than it was when new. In one of the beds unprovided with a false floor it was found that after 19 months' working there was an accumulation of 2 ins. of humus resting on the concrete floor.

If the site for filters is not naturally such as to settle the question whether the percolating beds should be above ground, it is not worth while to excavate a large area simply to enable the filters to be built above ground. After considerable experience of beds under ground level, and of beds enclosed within brick and mortar walls, I have come to the conclusion that there is no benefit to be obtained from open sides, in so far as aeration is concerned, so long as provision is made to allow a current of air to circulate freely underneath the medium, and this is best done by adopting the aerating tile.

This conclusion has induced me to further increase the area unit from one acre to nearly two acres, and in the case of storm water to nearly 15-acre beds.

In large schemes it will probably be found economical to clear the whole site to the level chosen for the floors, and build rubble walls round the beds for the purpose of retaining the media.

At first sight a wall may appear to be unnecessarily expensive, and that economy would be gained by allowing the medium to slope on a natural angle of repose from the top to the bottom of the bed. Dr. Barwise has openly advocated this for economical reasons. As I am responsible for a greater length of those enclosing walls than any other engineer, it may be of interest to many to know that my reason for building retaining walls is chiefly economical. These need not be built solid of stone and lime, as dry stone building will be found cheaper and quite strong enough if skilfully bonded. Walls of dry rubble round rectangular beds of an acre area to retain 6 ft. of medium cost £244, whereas sloping medium for a similar bed would cost £500, and in the case of circular beds the disparity is not less and the cost is even greater—£356, against £700. The cost of construction is double, and the area lost where land is limited amounts to one acre per eight acres of rectangular beds constructed. In the case of circular beds the area lost is even greater.

The chief object of employing medium is to provide a habitat for the bacteria, and, after obtaining suitable media, the chief desideratum should be the permanence of the bed. This, it is obvious, could not be obtained by employing a medium that would either break down and be washed out with the effluent or clog up the interstices of the bed. At Manchester furnace ashes were employed, and there it is found that this material requires to be taken out and washed and replaced every five years, at a cost of 1s. 6d. (35 cts.) per cu. yd. Besides the cost there is the gradual choking up of the beds, the constant state of disorder produced on the works, and the ever-increasing accumulation of fine ash and spent humus of irreducible residuum of the septic process to be got rid of.

This figure of 1s. 6d. per cu. yd. every five years agrees fairly well with the Birmingham expense, where about two acres have just been washed at a cost of 11d. (22 cts.) per cu. yd., but there the motive power employed in washing was obtained from an electric power installation, which would have had to be maintained whether washing took place or not, and to the cost of washing there falls to be added the cost of renewals to take the place of what is washed out as dust—6d., total 1s. 5d., as against the Manchester 1s. 6d.

A percolation bed for the purification of sewage should be an absolutely permanent structure that requires no renewal and no displacement for cleansing purposes, and this can be obtained only by the employment of good rock or other hard substance that will not resolve or become friable by the action of water or atmospheric changes. The qualities of medium next in importance are roughness of surface and pieces that proximate to cubes.

There is nothing better than clean broken stone, but gravel, blue bricks, and hard ball slag, when broken and clean, may be regarded as almost equally permanent. The blue brick tends to break into flat chips in the cracker, and gravel, unless broken, presents too smooth a surface to the bacteria; not that a smooth surface is not generally good, but it is too sensitive to be held in high estimation as a medium.

The sizes to which medium should be broken can only be decided after prolonged and careful tests, and a size suitable for one sewage may be quite unsuitable for another. The nature of the effluent, the depth of medium required, the quantity of sewage the bed is capable of purifying, the periods of rest necessary, and facilities for removing suspended solids, either from the surface of the bed or by eliminating them from the effluent, all have a direct and reciprocal bearing on the size of medium employed.

It may safely be assumed that the smaller the medium the more complete will be the purification obtained, but a bed composed of small medium (⅛-in.) costs about twice as much as medium size (1-in.). Then the small medium will not take so much sewage, it will require longer periods of rest, and it will retain on the surface suspended matter, which can be more economically dealt with in a separator tank.

In all sewage there are impurities that are readily eliminated, as gas. There are also impurities that undergo change with extreme slowness, such as colloids, and through recent investigations there is reason for believing that it is this matter that causes the notorious loss of capacity of contact beds, and constitutes the bulk of the suspended matter issuing from percolation bacteria beds. Those who are specially interested in the effect of colloidal matter in sewage should see the published papers of Dr. Fowler, Dr. Travis, and Mr. O'Shaughnessy. I am convinced, however, that until now there has been ignorance regarding the real nature of the clogging of contact beds, and the more the subject is investigated the more it will be seen that the safest form of bacteria bed is one which allows the bed to perform the natural function of discharging the matter which is due to the chemical change that takes place in a sewage containing colloidal matter. Some prefer to eliminate the solids from the sewage before it is applied to the oxidizing beds, even if they have to use chemicals for the purpose, but this is not so obviously wise as would appear at first sight—

*Slightly condensed from a paper read Sept. 7, 1906, before the Annual Congress of the Incorporated Sanitary Association of Scotland, at Leith.

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e. g., one bed (B) has during the last eight months been fed by a sewage containing about 7 parts per 100,000 of suspended solids, and the effluent or filtrate during the same period contained 8 parts per 100,000, as may be seen from Table I., thus showing

TABLE I.

Showing amount of suspended solids in tank liquor as applied to bed B, and the amount of suspended solids in the filtrate after biological treatment.

Monthly Averages for Year 1906.

	Tank liquor.	Filtrate.
January	3.6	3.9
February	5.2	5.6
March	5.4	15.7
April	7.2	6.9
May	7.8	9.8
June	8.6	7.7
July	8.1	7.5
August	6.7	7.1
Average	6.5	8.0

that iron or some other substance in solution when the sewage was applied to the oxidizing bed is transformed into suspended solids when it leaves the bed as filtrate. After all our experience and investigation, it must be admitted that we do not yet know exactly what a bacteria bed is capable of. All reliable evidence at present goes to show that such matter cannot be eliminated in the bed in a reasonable time, and I am driven to the conclusion that the only safe course for an engineer to adopt is to construct a bacteria bed so that solids may be easily removed. This points to the conclusion that medium must be of such a size as will allow solids to pass through it with the effluent.

Two years ago I favored a 2½-in. medium, with a layer of small size (½-in. to ¾-in.) near the surface. Since then I have come to the conclusion that ¾-in. to 1¼-in. or 1½-in. size is more economical, and equally good, if not better, from a purification point of view, and it is not too small to impede surface flushing—a point of the utmost importance.

Dr. Reid, the medical officer of health of Staffordshire, has succeeded in producing excellent results at Hanley on oxidizing beds which are built of very fine medium (⅛-in. particles), and, as may be expected, the effluent is free of suspended solids; not only so, but the quantity of tank liquor distributed over the bed is large, viz., 200 (240 U. S. gals.) gals. per sq. yd., and the work has gone forward without interruption for eighteen months. This is a marvelous result, and I have put down a bed on similar lines one-seventh of an acre in area for experimental purposes. So far my results do not come up to those of Dr. Reid, but the Hanley sewage and the Birmingham are entirely different, as may be seen from the following analyses:

	Birmingham.	Hanley.
Number of records	52	18
Total solids	—	170.9
Dissolved solids	113.9	—
Solids in suspension (total)	71.4	63.5
Solids in suspension (organic)	40.5	28.5
Free ammonia	4.946	2.154
Albuminoid ammonia	1.716	0.972
Chlorine	21.3	11.0
N. and N. as nitrogen	.893	.129 (?)
Oxygen absorbed in four hours (filtered)	17.169	(?)
Oxygen absorbed in four hours (unfiltered)	31.158	5.019

A sewage almost devoid of colloids, and having an oxygen-absorbed figure of 5, as compared with 31, is certainly more likely to show well on a fine-grain filter than would a sewage like that of Birmingham.

I have said enough to indicate the trend of Dr. Reid's investigations, and the next few months will confirm or disprove the opinion I now hold, that very fine media may only be used when the sewage is of an exceptionally weak character.

When the sewage is exceptionally weak, and it is determined to use fine media, it will probably be found that the bed need not be more than 4 ft. deep. The following table seems to bear this out:

HANLEY.

	Albuminoid ammonia.	Oxygen absorbed.
First ft. of filter	0.052	.328
Second ft. of filter	0.037	.286
Third ft. of filter	0.031	.244
Fourth ft. of filter	0.027	.259

The question of distribution of sewage over the surface of the beds is one of the most important, and designers of distributors should aim at fulfilling the following conditions:

(1) Uniformity of distribution so that each portion of the area may receive the same quantity of liquid.

(2) Delivery of liquid by the distributor in the form of rain drops.

(3) Absolute control of distributor.

(4) Reasonable capital cost.

(5) Minimum of moving or working parts.

(6) Minimum of working cost.

(7) Small expenditure of energy to distribute the liquid.

After careful consideration I have come to the conclusion that for large beds the fixed spray jet is the best method of distribution at present available.

Self-propelled distributors are, so far, unsatisfactory, as the power developed is not sufficient to drive the machines in windy weather without applying more sewage to the beds than they are capable of dealing with.

Spray jets have been improved by Mr. Bryan and Messrs. Jones & Attwood until they are now both efficient and cheap. When a head of 5 ft. or 6 ft. can be obtained, and the area is not less than one acre, no hesitation need be shown in adopting spray jets in preference to any mechanically-driven distributor at present on the market.

Theoretically, the nearer the distribution of sewage over the beds proximates to rain drops the better. It has been urged by one or two of my friends that distribution by means of the fixed spray jet, while fulfilling this condition, creates more smell and a greater possibility of distributing pathogenic micro-organisms over a larger area than is the case with rotary distributors. I have not found this fear to be well founded, but in designing new works it is well to take into account objections of this kind, as even sentiment—aye, unreasoning and unreasonable sentiment—must be respected.

In constructing beds for circular distributors no part can be brought into use until the whole is ready, thus involving the locking up of a large capital for, perhaps, a few pounds' worth of uncompleted work for an indefinite time. With rectangular beds, on the other hand, the work of distributing sewage over the medium may go on at one end of the bed while medium is being placed in the other. A bed may be divided into several bays (say, five, six or seven), and in practice it not infrequently happens that bay No. 1 is at work while bay No. 2 is being filled with medium.

Another advantage of this method of construction admits of one bay resting while the others are at work; this advantage should be more appreciated on a comparatively small installation than on a large one.

By this system, also, the distribution is under perfect control, and improvements made in the form of the spray jet may be readily adopted at any time without interfering with the system, as the jets themselves cost only £25 ($120) per acre, when the available head is not less than 5 ft. These jets are readily fixed into bosses cast on the distributing pipes, the bosses being bored and the jets turned slightly conical to admit of easy removal.

On the sewage question, more than on any other perhaps, it is wise to keep an open mind, and to avoid bolstering up a case in order to show that one's own forecast, whether optimistic or pessimistic, was accurate. Still one must act on ascertained fact and experience, and where there is doubt err on the cautious side. For this reason I advocate the use of medium-sized medium against the use of small particles and the subsequent arresting of the solids contained in the filtrate in a tank called the Birmingham separator, the construction of which I shall explain anon.

For a considerable time I have been suspicious of the fine clear sparkling effluents obtained from some of the percolating beds, and feared the dawn of a day when the fine effluent would have to be paid for by a serious chokage in the bed itself. I therefore have encouraged effluents that contain as much suspended matter as the tank liquor contained when it was distributed over the surface of the bed, believing that under such conditions there is security against chokage of a bed.

This naturally led to the question whether the solids in the filtrate must be allowed to flow into the river or whether they could not be disposed of in some other way. Experiments were therefore made on:

(1) Downward sand filtration.

(2) Upward sand filtration.

(3) Sedimentation in long shallow trenches.

(4) Sedimentation in shallow reservoirs.

(5) Sedimentation in deep tanks (Birmingham separator).

By the first experiment it was shown that practically all the suspended matter was capable of removal, but at an enormous cost, not so much in initial outlay as in the cost of keeping what would practically be great areas of water-works filters in effective condition.

By the second experiment, which was undertaken to obviate the cost of scraping the surface of the sand filter, it was shown that the filtrate, taking the line of least resistance, forced its way through weak points in the sand bed, leaving great areas of the sand unworked. Purification was therefore effected to a very slight extent.

The third experiment was fairly successful, the bulk of the suspended matter being removed, but it would have required too great lengths of channels and very frequent cleaning of those channels to effect the necessary purification.

The fourth method was quite practicable, but it was proved that the reservoirs would require to be of considerable size, and in order to effect periodical and efficient cleansing it would have been necessary to construct the works in duplicate.

While puzzled over the difficulty I concluded to try a tank constructed on the principle of the silt tanks, and I am glad to say it has been very successful in accomplishing what was wished, and at a cost that does not exceed 1s. 6d. per 1,000,000 Imp. gals. passed through it. (30 cts. per 1,000,000 U. S. gals.) The existing tanks are designed to deal with a daily flow of 10,000,000 gals. (12,000,000 U. S. gals.), and others to treat a similar quantity are in course of construction.

The tanks are rectangular in plan, the side walls being vertical for a distance of about 7 ft. from the coping, the remaining portion of the tank being constructed in the shape of an inverted pyramid, and terminating in a small sump about 4 ft. square and 2½ ft. deep, from which point the sludge is extracted. The inlet pipe enters at the side at the bottom of the vertical walls, and is carried to the center of the tank, where it dips downward for a depth of 5 ft. The pipe is supported near the center of the tank by means of a steel trestle. The outlet to convey the effluent from the tank is in the form of a weir constructed the whole length of one side.

The sludge is removed by means of a sludge pipe extending down the side of the tank and into the sump at the bottom. The outlet from this pipe is situated about 4 ft. below the water level in the tank, and by opening a valve the sludge is forced up the pipe from the sump.

The water enters through the inlet pipe with a downward velocity of between 1 and 2 ft. per sec., and after spreading out laterally rises up the sloping portion of the tank with a gradually decreasing velocity. As this velocity approaches the falling velocity of the suspended particles these become separated out, tending neither to rise nor fall, and this separation takes place throughout the sloping portion of the tank.

Experiments have shown the most suitable speed of upward flow in order to obtain the best sedimentation is 21 ft. per hour.

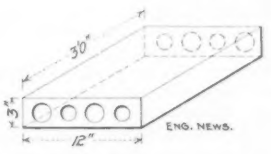
Theoretically, the upper part of the tank with vertical walls is not required, as the efficiency of such a tank as regards the separation of suspended matter depends solely on the surface area. It has been found advisable, however, to make this portion from 5 ft. to 7 ft. deep, as the separation of such suspended matter as the tank is capable of does not cease absolutely at the termination of the sloping portion. The only effect of increasing the depth beyond this point would be to further compress the sludge in the bottom. When the sludge valve is opened the upward flow of the water ceases, or may possibly become a downward flow, according to the rate of outflow. The suspended matter which has been separated out in the tank then falls to the bottom. It has been found possible with this form of tank to remove an amount of suspended matter from the effluent averaging about 85% of the total.

A FIRE TEST OF PLASTER BLOCK PARTITIONS.

A very successful fire test was conducted Oct. 8 under the supervision of the Bureau of Buildings on plaster fiber-block partition walls erected at the Columbia Fire Testing Station, New York City.

An inclosed structure with side walls about 14 ft. long and 12 ft. high built of these blocks, was used for the test. One of the side walls was constructed entirely of 3-in. blocks, cored as shown in the accompanying illustration and having the dimensions there indicated. Each block weighed 28 lbs., and was composed of 25 lbs. of plaster, 2¼ lbs. of excelsior, and ¾ lb. of shavings.

The other side wall was built entirely of 4-in. blocks, which otherwise had the same dimensions and was cored the same as the block here shown. The weight of each 4-in. block was 34 lbs.; of this the plaster weighed 30 lbs., the excelsior .3 lbs., and the shavings 1 lb.



Plaster Fiber-Block for Inside Partition Work.

The walls were built about one week before the test, but damp weather prevailed during most of that time so the blocks had not become thoroughly dried out. During the first half hour of the test the fire within was brought up to a point where the temperature recorded by pyrometers projecting through the two side walls and the top was 1,700° F. Platinum-rhodium couples were used, and wires from these were led to a millivoltmeter calibrated in degrees Fahrenheit and mounted in a small building about 25 ft. distant from the test structure.

During the second half hour of the test the temperature within was maintained constant at 1,700° F., and then the end door was opened and a stream of water directed at the inner surface of the side partition walls. The test was entirely

satisfactory in that there were no cracks, and no fire or water penetrated the walls. The International Fire-Proofing Co., of Brooklyn, N. Y., manufacture these plaster fiber-blocks for inside partition work.

LEDGER ACCOUNTS IN RAILWAY ENGINEERING WORK.

At the annual meeting of the American Railway Engineering and Maintenance of Way Association there was some discussion as to the advisability of the engineering department of a railway keeping ledger accounts of the cost of individual pieces of construction and maintenance work. The general opinion appears to be decidedly in favor of such a system, although the methods of carrying it into effect are exceedingly diverse. A card-index method of keeping these accounts was described in Engineering News for Aug. 2, 1906. There are, however, strong opponents of the system, who consider that the cost and labor involved would far outweigh any advantages to be obtained by the possession of these records. Following the presentation of the report on this subject at the meeting above mentioned, written discussions were invited, and a compilation of these is given in Bulletin 76 of the Association. Some extracts from these are given below*:

ILLINOIS CENTRAL RY. (A. S. Baldwin, Chief Engineer).—We have in use a system of authority blanks covering maintenance work on bridges and water-works. The system consists of a formal authority issued from this office covering work other than regular maintenance work. Each authority bears a specified number, and as they are issued, record is made of the amount of the authority in a book provided for that purpose, and the division officers report at the close of each month to the auditor of disbursements the amounts expended on each authority during the month. These are consolidated in the auditor's office and the total amount expended transmitted to this office as soon thereafter as possible, by the auditor. When this statement is received from the auditor it is entered in the before-mentioned book, sheets from which are enclosed. The benefit received from individual ledger accounts is to enable a sufficient amount of supervision to be kept on expenditures to prevent division officers from overrunning their accounts. It would be impracticable to do without this, I believe, on construction authorities and it is also of grea value as a check on repair authorities.

PHILADELPHIA & READING RY. (W. Hunter, Chief Engineer).—Division superintendents keep a memorandum book of individual pieces of work, made up from the reports of the supervisors and section foremen. These items are collected, showing the cost of the particular work done, as per requisition. Under the account heading, "Improvement Expenditures," they are reported to the auditor of disbursements.

On the general ledger only one account is kept, "Improvement Expenditures." This does not include the cost of constructing new or branch lines, extensions of existing lines, expenditures for additional rolling stock or marine equipment, nor improvements that may have a special earning power. There may be items of work involving questions of financial policy as to whether they should be charged to capital account in accordance with the usual classification of construction expenses, or whether the property of the road should be improved out of current earnings and charged to operating expenses, under account, "Improvement Expenditures," other than to merely keep up the general standard of efficiency; these are disposed of according to the direction of the management and are charged to specific accounts as may be arranged.

NASHVILLE, CHATTANOOGA & ST. LOUIS RY. (Hunter McDonald, Chief Engineer).—Except in the case of an improvement or betterment, no ledger accounts are kept of any individual piece of work. Such accounts for improvements and betterments are kept in the office of the comptroller, the entries showing the dollars and cents and the sources of the charge, such as payroll, store house, road stock, etc. We formerly kept individual accounts of all bridges and trestles on the road, but after ten years' experience have concluded that it is not worth while to do so. Our present practice is to keep a complete record of all work done on each structure, on the forms for bridges, trestles and culverts. No effort is made to keep account of the dollars and cents. The price of material and the efficiency of labor vary with the demand therefor. The record of the cost of the work in the past is, therefore, of little value for work in the future, and I know of no other use to which individual accounts could be kept.

LOUISVILLE & NASHVILLE RY. (W. H. Courtenay, Chief Engineer).—Itemized accounts are kept by the accounting department of the cost of the work. The benefit derived from such accounts is to enable us to check the cost of the work. It is often important to know long after a certain piece of work has been completed, what the cost was, and the detail of the cost.

CANADIAN PACIFIC RY. (F. P. Gutelius, Engineer of Maintenance of Way).—It is not the practice on this railway to keep ledger accounts in the engineering offices. These accounts are kept by the superintendent's accountant and monthly statements, showing amounts expended on each piece of work, are furnished by the accountant to the resident engineer. This system seems to be satisfactory and we would not recommend ledger accounts in the engineering office.

PENNSYLVANIA LINES WEST OF PITTSBURG, SOUTHWEST SYSTEM (W. C. Cushing, Chief Engineer Maintenance of Way).—Structure reports showing detail of material used and cost of labor are prepared by the foreman in charge of each particular piece of work on which he was engaged during the month. The reports are approved by the master carpenter or master mason and forwarded to the office of engineer maintenance of way on completion of work, or at the end of the month if the work is not completed during the current month. The cost of material is placed on reports in office of the engineer and charges are then entered in the ledger in brief detail under appropriate captions, together with other charges which do not appear on structure reports, but originate from shop bills, accounts payable and other sources handled direct in the office of the engineer maintenance of way. After being entered in the ledger, structure reports are filed by months for future reference.

On the Pittsburg Division, individual ledger accounts have been found a very valuable adjunct to our records, especially on account of the numerous changes in the personnel of the office force. They furnish a permanent and ready reference that gives necessary details of cost of any important work done and forms a reliable precedent for estimating cost of future work of a similar nature. The benefits derived from individual accounts greatly exceed the expense of recording them.

LOUISIANA WESTERN RY. (E. B. Cushing, General Superintendent).—It is our practice to keep a detailed record of cost of all individual pieces of work chargeable to construction and improvement accounts, also to jobs chargeable to operating expenses, in excess of $100. This record is kept in an ordinary stock journal and all charges to different jobs are posted in same monthly. On pieces of work where this record is kept, work order is prepared by the department under whose supervision the work is to be done. After said work order has been approved by the general superintendent, it is forwarded to the auditor, who keeps a detail of all charges against each job. The benefits received from the individual ledger account system are commensurate with the expense in a number of respects, as follows: (1) It induces a more careful accounting for material and labor expended by those supervising the work as they may be required to explain abnormal difficulties between the estimated and actual cost; (2) it affords the accounting department a closer check on the reports of material and labor expended; (3) it places a permanent record carrying a detail exhibit of cost of each job within easy access of the management.

BOSTON & MAINE RY. (J. P. Snow, Bridge Engineer.)—Ledger accounts for individual pieces of work are not kept except in cases where such work is charged to construction or improvement account. In these cases the items are drawn off on sheets monthly, during the progress of the work and reported to the general auditor. Construction work is done under special appropriations and the above charges are checked against the appropriations. The cost of sidetracks built for outside parties are ledgerized in a general book where an account is kept separately for each such track. The benefit of keeping individual ledger accounts, except as above, is not commensurate with the expense involved under the Boston & Maine Ry. system of accounts.

CENTRAL RAILROAD OF NEW JERSEY (Joseph O. Osgood, Chief Engineer).—The present practice is to keep the details of the various classes of work in our construction ledger and on completion of the work a final bill is rendered showing the cost of each subdivision of work, viz.: grading, tracklaying and surfacing, handling material, etc. The benefit received from individual ledger accounts is that the cost of any particular branch of the work may be determined during the progress, as well as total cost to any date, and the benefit is without doubt commensurate with the expense.

PENNSYLVANIA R. R. (Joseph T. Richards, Chief Engineer of Maintenance of Way).—All detailed records of individual pieces of work are kept by the comptroller in the accounting department, making it unnecessary for anyone else to keep a duplicate record, particularly for the reason that a copy of the monthly list showing items of work authorized, the amount of the appropriation and the amount spent to date is furnished each general superintendent. We keep a copy of all bills, together with a copy of our statements of charges for labor, etc., which are in addition to charges originating in the shape of bills.

NORFOLK & WESTERN RY. (Charles S. Churchill, Chief Engineer).—We do not keep what may be strictly called ledger accounts. We advance the records, however, as far as what might be termed a journal and these records are left in such shape that we can at any time secure the cost of any piece of work. While we think it very important to have record of cost of individual pieces of work, we doubt the expediency of going much further into ledger records than we do. We think that it is very important to determine promptly the cost of any piece of new work and our accounts are kept so that we are able to do this.

*Copies of the report and discussions (accompanied by examples of the blank forms and methods of accounting employed) may be obtained from the Secretary of the Association, Mr. E. H. Fritch, 962 Monadnock Block, Chicago.

THE COMPUTATION OF HEIGHT OF BACKWATER ABOVE DAMS.

By D. M. Andrews,* M. Am. Soc. C. E.

The increasing development of water powers on large streams in the United States, and the construction of important dams in connection therewith, brings to the engineer a realizing knowledge that riparian rights have to be reckoned with; and one of the first problems that confronts him in the study of such a development is the ascertainment of the probable damage to riparian owners by the backwater from his proposed dam. The writer has had considerable experience with this subject of backwater, and submits the methods employed by him for its solution, in the hope that they may be helpful to others of the profession who may have to do with the problem.

He lays no claim to originality, unless his determination of a new value for the constant m in the Weisbach formulas, applicable to dams in large streams, can be considered as such.

In all his computations of overfall at dams, he has used Weisbach's formulas, as given in Vol. 2, pp. 108 and 109 of Du Bois' translation of Weisbach's "Mechanics of Engineering and Machinery." In his formulas Weisbach gives the value of the constant m as .80, but the writer by experiment at several existing dams has found that a value of .70 gives better results for dams in large streams.

To compute the probable overfall at any proposed dam, the following data must be available: the height and length of the dam; the height of the water just below the dam, i. e., the gage height, and the discharge of the stream at the proposed site, corresponding to the gage height. The height and length of dam are fixed by the engineer; the gage height and discharge must be observed; but, with the very extensive and efficient system of stream measurements now in progress by the Hydrographic Division of the United States Geological Survey, the discharge can frequently be gotten from the records of the Survey, at a point near enough to the proposed site for all practical purposes.

Weisbach's formula for weir dams, when not submerged, is:

$$h = \left(\frac{\frac{3}{2} Q}{m\, b \sqrt{2\, g}} + k^{\frac{3}{2}} \right)^{\frac{2}{3}} - k\,.$$

h = the depth of water on the crest,
Q = the discharge,
m = .70,
b = the length of the dam,
k = the head due to the velocity of approach.

The head due to the velocity of approach is to be neglected, for the height of the water surface above the influence of the velocity of approach is what is wanted, and, therefore, the equation becomes:

$$h = \left(\frac{\frac{3}{2} Q}{m\, b \sqrt{2\, g}} \right)^{\frac{2}{3}}$$

But if for any purpose it is desired to know the depth of water on the crest, the value of k can be determined and subtracted from the value of h as previously found.

*U. S. Engineer Office, Montgomery, Ala.

The equation for k is as follows:

$$V = \frac{Q}{b\,(h + d)}$$

$$k = \frac{V^2}{2g} = \frac{Q^2}{64.32\ b^2 (h + d)^2}$$

In this equation d = height of dam.

Weisbach's formula for submerged dams, i. e., dams whose crests are below the backwater, from below, is:

$$Q = m\,b\sqrt{2g}\left(\frac{2}{3}\left[(h_1 + k)^{\frac{3}{2}} - k^{\frac{3}{2}}\right] + (h - h_1)(h_1 + k)^{\frac{1}{2}}\right).$$

Reversing and reducing, we have,

$$(h_1 + k)^{\frac{3}{2}} - k^{\frac{3}{2}} + \frac{3}{2}(h - h_1)(h_1 + k)^{\frac{1}{2}} = \frac{3\,Q}{2\,m\,b\sqrt{2\,g}}.$$

Neglecting the head due to the velocity of approach, the equation takes the form,

$$h_1^{\frac{3}{2}} + \frac{3}{2}(h - h_1)\,h_1^{\frac{1}{2}} = \frac{3\,Q}{2\,m\,b\sqrt{2\,g}}$$

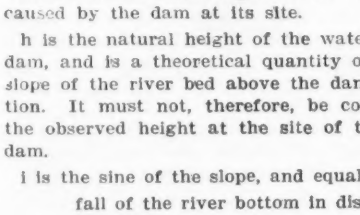


Fig. 1.

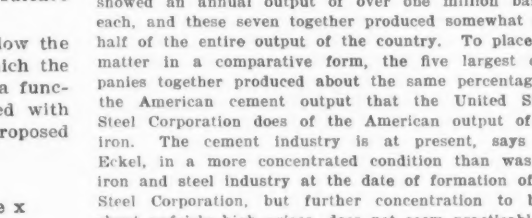


Fig. 2.

BACKWATER FROM PROPOSED DAM.

In this equation h — h₁ is the backwater on the dam, from below, and is known, as is also the second term of the equation, therefore,

$$\text{let } x = h_1^{\frac{1}{2}},$$

$$p = \frac{3}{2}(h - h_1),$$

$$q = \frac{3\,Q}{2\,m\,b\sqrt{2\,g}},$$

and we have the cubic equation, $x^3 + p\,x - q = 0$.

Solving by Cardan's rule we have,

$$x = \sqrt[3]{\frac{q}{2} + \sqrt{\frac{q^2}{4} + \frac{p^3}{27}}} + \sqrt[3]{\frac{q}{2} - \sqrt{\frac{q^2}{4} + \frac{p^3}{27}}},$$

and

$$h_1 = \left(\sqrt[3]{\frac{q}{2} + \sqrt{\frac{q^2}{4} + \frac{p^3}{27}}} + \sqrt[3]{\frac{q}{2} - \sqrt{\frac{q^2}{4} + \frac{p^3}{27}}}\right)^2.$$

The height of water over the crest can be found, if desired, by subtracting the value of k.

The relation of the symbols employed in the Weisbach formulas are shown in Fig. 1.

The equation for finding the height of the water surface at a known point above a dam, and thereby the slope of the water surface between that point and the dam, is that of Poirée, which is given in his "Manual de l'Ingenieur," Vol. 19, p. 159, and can also be found in De Lagrene's "Navigation Interieure." A discussion of this subject of overfall and slope in its application to special dams can be found in Part 2 of the Report of the Chief of Engineers, U. S. A., for 1887, p. 1305 *et seq.*

Poirée's formula is,

$$D = H + h - i\,x + \frac{(i\,x)^2}{4\,H}$$

D is the depth at a point above a dam whose distance is x.

H is the increased height of the water surface caused by the dam at its site.

h is the natural height of the water below the dam, and is a theoretical quantity of which the slope of the river bed above the dam is a function. It must not, therefore, be confused with the observed height at the site of the proposed dam.

i is the sine of the slope, and equals,

$$\frac{\text{fall of the river bottom in distance x}}{\text{x}}.$$

In this equation H + h, i and x are known, but h must be found by calculation.

We will use the Chezy formula with 100 as coefficient.

$V = 100\sqrt{r\,i}$.

r = mean hydraulic radius,

i = slope of river bottom,

but we have

$$r = \frac{b\,h}{b + 2\,h},$$

and

$$V = 100\sqrt{\frac{b\,h\,i}{b + 2\,h}}, \text{ also } V = \frac{Q}{b\,h};$$

therefore

$$100\sqrt{\frac{b\,h\,i}{b + 2\,h}} = \frac{Q}{b\,h}$$

which may be reduced to

$$h^3 - \frac{2\,Q^2}{10{,}000\ b^3\,i}\,h - \frac{Q^2}{10{,}000\ b^2\,i} = 0.$$

Let

$$\frac{2\,Q^2}{10{,}000\ b^3\,i} = p,$$

and

$$\frac{Q^2}{10{,}000\ b^2\,i} = q,$$

and we have the cubic equation,

$$h^3 - p\,h - q = 0.$$

Solving by Cardan's rule, we have

$$h = \sqrt[3]{\frac{q}{2} + \sqrt{\frac{q^2}{4} - \frac{p^3}{27}}} + \sqrt[3]{\frac{q}{2} - \sqrt{\frac{q^2}{4} - \frac{p^3}{27}}}$$

Usually, however, the value of $\frac{p^3}{27}$ is so small it can be neglected, and then,

$$h = q^{\frac{1}{3}}$$

Substitute the value of h, thus found, in the Poirée formula, and the value of D can be determined. The relation of the symbols in the Poirée formula is shown in Fig. 2.

In the practical application of the Poirée formula, it is necessary to exercise great care in order to get approximately accurate results. Whenever one or more prominent reefs or other obstructions or contractions intervene between the site of the proposed dam and the known point, the depth of water or D just below each, beginning with the one nearest the site of the dam, must be found by the Poirée formula, and the overfall computed by the Weisbach formula for submerged dams, until the known point is reached at the known distance x from the site of the proposed dam.

CEMENT PRODUCTION, like steel production, has become concentrated in the hands of a few great producing companies. According to Mr. E. C. Eckel, of the U. S. Geological Survey, of the 78 companies which made cement in the United States in 1905 there were 15 which produced two-thirds the entire output. Seven of these showed an annual output of over one million barrels each, and these seven together produced somewhat over half of the entire output of the country. To place the matter in a comparative form, the five largest companies together produced about the same percentage of the American cement output that the United States Steel Corporation does of the American output of pig iron. The cement industry is at present, says Mr. Eckel, in a more concentrated condition than was the iron and steel industry at the date of formation of the Steel Corporation, but further concentration to bring about unfairly high prices, does not seem practicable.

The above figures are taken from a contribution in the forthcoming annual report by the Survey on the "Mineral Resources of the United States," in which a chapter is devoted to the cement industry.

SEWAGE TREATMENT AT MANCHESTER, ENGLAND, DURING THE YEAR 1905-6.*

The sewage of Manchester, England, is treated at three separate works known as the Withington, Moss Side and Davyhulme. Of these the Davyhulme works are by far the largest and are the ones generally known by American engineers. The Moss Side works make use of chemical precipitation, followed by a treatment of part of the effluent on land. The sewage from these works will soon be diverted to Davyhulme. The net cost of their operation for the year was about $7,500. The Withington works treat the sewage from some 56,000 people, of whom 17,000 reside in an adjoining municipality. The treatment is by means of detritus tanks, sedimentation tanks, and primary and secondary contact beds. A considerable part of the sewage is pumped, the power for pumping being obtained from heat from refuse destructors. The destructor furnaces consumed on the average 33 long tons "of ash-pit refuse per 24 hours." This fuel was supplemented with coke. The dry-weather flow of sewage at these works is about 3,600,000 U. S. gals. per day. The average daily flow, including storm water, for the period from April 26, 1905, to March 28, 1906, was estimated at about 6,000,000 U. S. gals. per day. The contact beds have areas of about ½-acre each, making a total of some 12 acres, besides which there are 2½ acres of storm-water filters. The average cost of sewage treatment per 1,000,000 U. S. gals., for the year, was in round numbers $11; this included sludge and refuse disposal, pumping and various incidental expenses.

The sludge at the Withington works is lifted by an injector and distributed to trenches through a cast-iron main. After drying, the sludge in the trenches is covered with earth and the land is subsequently plowed and cultivated. An average of 11.65 short tons of sludge per 1,000,000 U. S. gals. of sewage was produced during the year. The average flow through the sedimentation tanks occupied 3¾ hours. Four men are employed on the beds, scraping, forking and weeding the beds in rotation.

As already stated, the main sewage works are at Davyhulme. The sewage at these works first passes through screens and catch pits, where coarse floating matter and heavy detritus are removed. It then goes through open septic tanks and on to half-acre bacteria beds, or else is subjected to simple sedimentation, and is passed to storm filters. The sludge from the tanks either flows by gravity or is pushed by manual labor into channels leading to ejectors, from which it is forced to storage tanks near the Manchester ship canal and thence discharged by gravity into a sludge steamer, which carries it out to sea and deposits it beyond the Mersey bar. A small portion of sludge is pressed and subsequently disposed of to farmers. A total area of 183½ acres has been acquired for sewage works at Davyhulme, of which 46 acres have been laid out in primary contact beds and 26.8 acres are occupied by storm-water filters. This, as we understand it, comprises the full complement of first contact and storm filters, but thus far only ½-acre has been laid out as a second contact bed. A considerable area of land has been purchased at other locations, some of which will be ultimately used for irrigation, provided irrigation is insisted upon after the full complement of second contact beds has been provided.

The average daily flow of sewage arriving at the Davyhulme works for the year ending March 28, 1906, was about 43,350,000 U. S. gals. The greatest daily recorded flow for the year was 113,280,000 U. S. gals., and the maximum rate of flow was nearly double this rate per 24 hours—at 6 a. m., Aug. 26, 1905. The total rainfall for the year covered by the report was about 29 ins. at the works, rain having fallen on 181 different days.

Of the total sewage flow for the year, about 1% was diluted by rainfall beyond the 5 to 1

*Based on the Annual Report of the Rivers Department (Mr. A. H. Scott, Chairman) of the City of Manchester for the year ending March 28, 1906.

limit set by the Local Government Board.* About 92% of the total sewage flow was filtered, and 7.85% of the flow not filtered was treated in the sedimentation tanks, so that only 0.15% of the total flow passed the storm-gate overflow without any treatment whatever.

The total cost of treating sewage for the year, including sludge disposal, filtration maintenance and renewal, coal and incidental expenses (less receipts), averaged $5.76 per 1,000,000 U. S. gals. Or the total cost per head of population was about 15½ cts. The filtration cost was at the average rate of $1.65 per 1,000,000 U. S. gals., of which $0.97 was for maintenance and $0.68 for renewals.

The sludge removed from the sedimentation tanks averaged 13⅓ short tons per 1,000,000 U. S. gals., for an average daily amount 13,345,000 U. S. gals. treated by sedimentation. The sludge removed from the septic tanks was at the rate of 10⅓ short tons per 1,000,000 U. S. gals., the average daily quantity of sewage passing these tanks having been 29,855,000 U. S. gals.

The average rate of working the primary contact beds was about 650,000 U. S. gals. per acre per day for the whole year. The single half-acre second contact bed was operated at the rate of about 1,045,000 U. S. gals. per acre per day during the quarter ending March 28, 1906, including all periods of rest. This was after the bed had become fully matured. It will be understood, of course, that this bed received effluent from the primary filter. The purification effected by the secondary bed was 65%, calculated on the effluent on the primary bed, and 90% calculated from the raw sewage, these figures being based on the albuminoid ammonia determinations for the last quarter of the year. The filtrate for this bed was without exception non-putrefactive after incubation for six days at 80° F.

THE DEVELOPMENT OF BLAST-FURNACE BLOWING ENGINES.†

By David E. Roberts,‡ M. Inst. C. E.

The first practical design of steam blowing-engine was of the beam type. That type has given good service, and to-day will be found in some of the older works still usefully employed. Although the beam type of engine was popular for many years, yet as the demands for higher air-pressures and greater speeds arose, there was a tendency to more directness of design than was obtainable through the medium of a beam. The steeple type was therefore brought out and has become almost a standard.

A recent well-known modification of the steeple engine is the quarter-crank system. In an ordinary steeple engine one entire deck of cylinders is planted adjacently upon a separate and independent pair of standards. This system has advantages in the way of facilitating repairs to pistons and rods, and in preventing stoppage of the whole engine from the breakdown of one portion. Also, owing to the relative crank displacement adopted, the loads in the steam and air cylinders are better timed and balanced, and an even turning moment results. The disadvantage of the system is that all stress goes through the crankshaft, none direct; and the engine takes up a great deal of room.

Two other developments of recent times are the blast-furnace gas blowing engine and the turbo-blower.

GAS ENGINES.

In 1894 attention began to be attracted to the use of blast-furnace gas in gas engines, and the following year saw its application for the purpose of driving a dynamo. Since then large sizes have been made, and recently many have been applied to blowing purposes, some in England, more on the Continent. American steel-makers also are now adopting them in considerable numbers.

About four times the actual work can be got out of furnace gas when used through a gas engine as compared with the ordinary method of using it under boilers; and in the future the gas engine should have no real competitor for blast-furnace blowing. The upkeep of gas engines in England is, however, at present heavy, repairs costly, and lubrication excessive. The running cost of water-cooling and gas-cleaning plant is high, as also is the first cost. Gas-cleaning has always been one of the standing troubles with gas-engine work. It can, however, now be effectually done by rotary washers, of which there are several good designs in use that reduce the quantity of dust to a negligible amount.

It is estimated that, by using gas direct in blowing engines, about 30% of the total gas given off the furnace will be available outside the plant itself, and where the same is marketable it should form a valuable asset. In a modern plant making 2,000 tons a week the spare power should amount to about 1,000 HP. continuously. Irrespective of the troubles mentioned, this saving will probably bring the gas engine into general use for blowing purposes in the future. Greater experience and improved design will doubtless make these engins just as reliable as the small gas-engine in everyday use, which, as is well known, runs over long periods satisfactorily with little attention.

TURBINES.

The turbine, though not so economical as the gas engine, and, due to the eddying effects of steam, no more economical than a high-class steam engine, nevertheless has many advantages. Its first cost is less than for a reciprocating engine of equivalent power. It takes very little room, and the outlay upon house and foundation is small. A point of value in the turbine, and one perhaps not generally recognized and appreciated, is the absolute steadiness of the flow of air. This is an important point, and some furnace managers attribute to it considerable improvement in the working of their furnaces. From the earliest times, steadiness of the air has been aimed at by the use of large mains, reservoirs, loaded pistons, water regulators, etc., but it is only perfectly obtained in the turbine blower. The running cost is very slight, there is practically no friction, and a very small oil bill. The oil that is used need not be chosen with that care which is necessary with oil to be put into the cylinders of an ordinary engine. There is also the advantage of an oil-less exhaust for condensing.

With regard to steam economy, in ordinary engines live steam is continually thrown against surfaces just cooled by the exhaust, and in older engines, with ports common to both inlet and outlet, the resulting loss is intensified. In turbines the steam is brought into contact with metal approximately the same temperature as itself. Then again there is a certain amount of leakage always taking place past the working valves of a steam engine, which amount has been recently set down as somewhat excessive. Losses that have in past years been attributed to condensation are now stated by experimenters to be largely due to leakage past the cylinder valves. The only leakage that can take place in the turbine is that going on through the blades.

SUMMARY.

It is not easy to state or even suggest general rules for the choice of a blast-furnace blowing engine. Sets of conditions can be found to which the ordinary steam reciprocating blowing engine is best suited, and this is also true with regard to the gas engine and the turbine. If the surplus gas from any given plant is in great demand, and can be used effectively on the spot, then gas engines have a great claim to consideration. On the other hand, there is probably no special advantage to be gained if this surplus gas cannot be so dealt with, although there are cases where the surplus gas is beneficially used for generation of electric power, the sale of which is a set-off to the working cost of the furnaces. It is hardly, under any circumstances, wise to apply gas engines to an isolated furnace, unless the expense of a gasometer and producers is permitted.

For augmenting the blowing power of an existing plant the turbine will be found well suited, and in many instances it can be applied without need of any further accommodation than the spare room frequently to be found inside many existing engine houses. The turbine in combination with ordinary reciprocating steam engines provides a system both safe and satisfactory, and one that is in many ways ideal; for if there is one weak feature in the turbine it is that of not being quite a "positive" blower, and there is also a slight falling away in volume and efficiency when the pressure increases above the "normal," as results from a "standing" furnace.

A point about blowing engines, which possibly does not receive the attention it should, is the correct ratio between the areas of the steam and blowing cylinders. Each locality from its own conditions of material, such as fineness of ore, hardness of coke, height of furnace, speed of driving, etc., demands a certain normal air pressure, which it is found prevails almost continually. The pressure will differ somewhat between one district and another. The blowing engine should be so designed, having regard to the steam supply available, as to be giving its greatest economy when blowing this normal pressure, special arrangements being made for dealing with the occasional increases of pressure that arise, in steam-engines by retarding the cut-off, and in gas engines by manipulation of the air inlet valve, or adjustment of the clearance space. This, however, in the opinion of the author, is not usually the case, and most modern engines will be found so proportioned as to be giving their greatest economy not when working upon the normal pressure but when working at a higher pressure than the normal, and one which occurs only occasionally. In most of the old engines the reverse of this was found, and possibly the constant grievance of the furnace manager, in not being able to obtain his "pillar" (pressure of blast), has in a measure been the cause of this over-reaching movement in the opposite direction.

*Three times the dry weather flow must be treated on the regular filters and the excess of this up to six times the dry weather flow on storm filters.

†Abstract of a paper read at the Cardiff meeting, 1906, of the Institution of Mechanical Engineers.

‡59 Queen Street, Cardiff, England.

AN UNUSUAL TRANSMISSION-LINE SUPPORT.

Difficult conditions for a high-tension transmission line were encountered along the banks of Lake Luzerne, in Switzerland, where a triple 25,000-volt transmission line, extending from Obermatt 16.7 miles to Luzerne, runs along a steep, rocky mountainside. The photograph (Fig. 1) herewith shows the means resorted to. The road seen in the illustration extends along the foot of a wooded precipice, on the immediate edge of the lake. The outer edge of the road is occupied by a telephone and telegraph line of some 20 wires, and it was necessary to keep the transmission line well away from these wires. At the same time, the bottom of the lake falls away so steeply that it is impracticable to set poles or towers any distance from the shore. The danger of occasional falls of trees or rock from the mountainside, again, made it advisable to keep as far from the mountainside as possible. The construction which appears in the photograph, comprising cantilever supports for the transmission-line towers, which carry the line

Fig. 1. View of Luzerne-Engelberg Power Transmission Line Along the Lopper Road, Shore of Lake Luzerne.

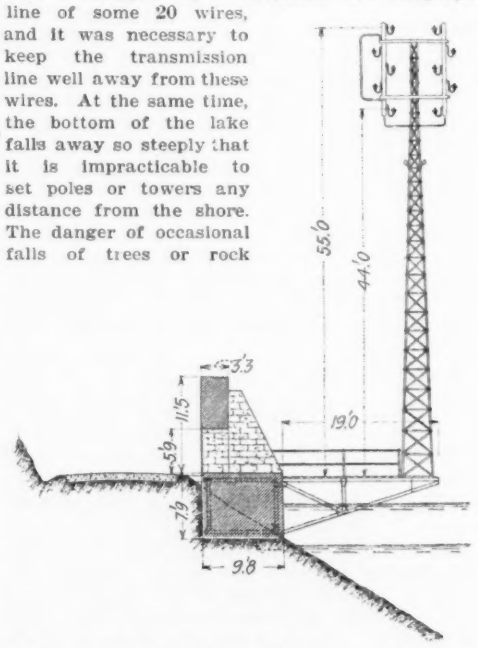


Fig. 2. Sketch of Transmission-Line Tower on Cantilever Support.

some 20 ft. out from the bank, was devised as a solution of these difficulties.

Fig. 2 shows one such cantilever and tower, as viewed in the direction of the line. The structural features will be self-explanatory. The masonry foundation and anchorage is topped with a wall on the land side to protect the pole against falls of debris from the hillside. In order to reduce the number of these special towers, the normal span length of 200 ft. was increased to twice this amount on the section concerned.

The pole-top used on this line is also of interest. Two transverse steel channels riveted to the tower carry two oak uprights at their outer ends. The insulator supports, of galvanized iron, are fixed to the uprights in staggered arrangement, with a spacing of 39 ins. between wires. On curves, iron guards as shown in the drawing surround the outer and bottom rows of wires. Further data on the line and the power plant (Luzerne-Engelberg power plant) may be found in the "Schweizerische Bauzeitung," from which the above is taken.

THE COBALT, ONTARIO, MINING CRAZE.

By J. A. McDonald.*

Surely the history of the Cobalt mining camp, when it has fulfilled its manifest destiny, will make curious reading. From the very first the camp has suffered from the fact that the ore is so rich that people will not believe the reports concerning it are true. When the first big discovery was made, now nearly three years ago, a professional geologist went to Cobalt and was so impressed with the new field that he published two articles over his own signature announcing in detail the nature of the remarkable discoveries. Very little attention, however, was paid to these articles.

During the summer of 1904 considerable prospecting of an amateurish nature was done in the region and a few wise men from the outside, officials of the new railway, and others, secured blocks of mineral land. Up to the spring of 1905 the press of Canada generally, let alone the outside world, did not know that there was such a thing as a silver camp in Northern Ontario. During the spring, summer and fall of 1905 there was quite a rush into the country, but, by that time, nearly all the locations worth having had been taken up and were being worked in a small way by owners who simply quarried out the silver on the surface and established bank accounts. In the spring of 1906 there was a great rush of prospectors into the Cobalt district and it was hoped that further discoveries would be made; but extensive prospecting has not thus far resulted in the discovery of any silver in Northern Ontario outside the limited territory of about six square miles at Cobalt. Then the boom "busted" so far as the army of prospectors was concerned, and they sloughed out of the country. But the dozen or so of rich shipping mines still remain, and this fact seems to have been generally overlooked since the boom burst.

It happens that the Jersey City smelters, to which the ore was shipped, had been robbing the Cobalt mine owners last year. At least the mine owners thought so, and as they had accumulated enough bank account to carry on development work, they have all this season been simply bagging their ore and storing it away in log huts, so that the public has heard nothing of phenomenally rich shipments. The one exception to this was the Nipissing mine, which is owned by Americans who are said to stand in with the Jersey City smelters. This mine has been shipping regularly, and that is probably how Wall Street came to hear about the Nipissing mine.

It was not until Nipissing mining stock jumped from $5 a share to its present figure $26.75 that the hall-mark was placed upon Cobalt silver. Within the past few days the Foster mine has been purchased right under the noses of an Ottawa syndicate which moved a little too slowly in getting up a deposit of $300,000, which was the amount Mr. Foster desired to see a bank certificate of before he would even talk business with the syndicate's representative. It is reported that the Americans who have the Nipissing mine have also got a controlling interest in the Foster mine for $750,000, a bargain-counter figure. At last reports there was $200,000 or $300,000 worth of ore stored on the property awaiting shipment, while the surface so far cleared off is fairly cicatrized with veins.

There are nearly a dozen mines at Cobalt that are regarded as being as good as the Nipissing or Foster, though they do not take in as much land. It would not be surprising to see them all bought out before next spring by Americans at high figures.

PERMANENCY OF THE CAMP.—Rich ore was blasted into in a crosscut on the 300-ft. level of the Timmins mine, on Oct. 2. It has an important bearing on the question of the permanency of the camp deposits with regard to depth. Most of the mining in the Cobalt regions so far has been on the surface; that is to say, few shafts are down over 50 to 60 ft. The 200-ft. level of the Timmins mine showed the vein wider than and just as rich as on the surface, and the recent discovery on the 300-ft. level, therefore, means much. The Timmins mine has already produced $400,000 in silver and one vein has been stripped for 800 ft., showing six to eight inches of almost solid silver for much of the way.

THE RIGHT-OF-WAY MINING CONCESSION.—The Temiskaming & Northern Ontario Ry. runs right through the heart of the Cobalt mining region, with the largest shipping mines close to the line. The railway right-of-way, therefore, is considered to be the richest mineral portion of the Cobalt camp. This right-of-way was recently sold, by tender, by the Commissioners of the T. & N. O. Ry. to an Ottawa syndicate for $50,000 in cash and a royalty of 25% on the output—for the privileges of mining the right-of-way only, of course.

Many thought at the time that the T. & N. O. Ry. Commissioners had made a good bargain, and even questioned the ability of the syndicate to realize anything from the concession. Now, however, it is stated that the reorganized company, before mining operations have begun, have been offered a million dollars for their property which covers about five miles of the railway right-of-way. Five veins of rich ore are known to cross the property, these veins running lengthwise with the railway for at least a thousand yards instead of crossing directly, as was at first supposed.

STOCK OF SHIPPING MINES A GOOD INVESTMENT.—For several months past the public has been warned from many sources against investing in "wild-cat" Cobalt companies, as nearly all of the stock offered, hitherto, was of that variety, for the simple reason that there was no stock of the "shipping" mines on the market. Most of these wild-cats have, however, died off. Now the stock of the real shipping mines is coming on the market in the wake of the Nipissing. The definition of a shipping mine is one that has been or is shipping ore, as distinguished from propositions that merely show indications.

The shipping mines are rapidly getting into shape for the winter campaign. In many cases new and larger machinery is being installed and additional camp houses are being completed. There is to-day sacked for shipment at the leading properties fully 20 car-loads of high-grade ore which will run from 1,500 to 3,000 oz. of silver per ton.

Cobalt is a wonderful mining camp and already can boast of proved properties of high and undoubted values. But these properties would need to be richer than the vaults of the Bank of England to carry the capitalization that is being loaded on them by the sale of stock at the rate of nearly $30,000,000 for one mine.

The accompanying table compares the capitalization, price and present value:

Name of Company.	Capitalization.	Shares. Par Value.	Shares. Market Value.	Present Market Value of Property.
Nipissing	$6,000,000	$5.00	$26.75	$32,100,000
Foster	1,000,000	1.00	3.00	3,000,000
McKinley-Darragh	2,500,000	1.00	3.50	8,750,000
Buffalo	900,000	1.00	2.30	2,070,000
University	1,000,000	10.00	15.00	1,500,000

*104 Queen St., Ottawa, Ont.

THE CLEVELAND TYPHOID FEVER EPIDEMIC OF 1903–1904.

During nearly the whole of the year 1904 and a part of 1905 Mr. George C. Whipple, Assoc. M. Am. Soc. C. E., conducted or directed an investigation of the relations between typhoid fever and water supply at Cleveland, O. The methods and results of this investigation are given at great length in the Annual Report of the Cleveland Water Department for 1905, just published. A paper based on these investigations was presented by Mr. Whipple, a few weeks ago, before the New England Water-Works Association, under the title given above.* The leading facts and conclusions of the paper are given below. Those deeply interested in the subject should consult the full paper.

Up to the early part of 1904 the water supply of Cleveland was taken from an intake crib in Lake Erie about 1¼ miles from the shore and 1 mile west of the mouth of the Cuyahoga River. Between Feb. 10 and April 7, 1904, the use of water from this crib was gradually decreased and there was substituted in its place (the substitution being complete on the latter date) water from a new intake crib located about four miles from the shore and nearly opposite the mouth of the Cuyahoga River, but distant by tunnel from the pumping station some five miles. During the whole of 1903 and the early part of 1904, typhoid fever in the city of Cleveland, always so high as to indicate an impure water supply, was very materially increased. The investigation conducted by Mr. Whipple seemed to show conclusively, to state results very briefly, that the excess of typhoid was caused by sewage pollution, chiefly from the sewage discharged into the Cuyahoga River. This conclusion was based largely on the fact that floods in the river, accompanied by wind blowing off shore, were shortly followed by increases in the reported number of cases of typhoid. The paper presents this evidence in detail.

The drainage area of the Cuyahoga River is about 805 sq. miles. Aside from sewage contributed by Cleveland, the river receives more or less sewage from Akron. The population per square mile on the entire drainage area is about 404, and the urban population is about 352. During freshets, large amounts of sediment "are washed into the harbor by the river."

The typhoid fever and other related statistics for Cleveland for the 33 years 1873-1905, inclusive, are given in Table I., and the monthly distribution of typhoid deaths from January, 1890, to June, 1905, is shown by Table II. For the 32 years from 1873 to 1904, inclusive, the average typhoid rate per 100,000 was 52, and the range was from 21 to 114—the latter figure having been reached in 1903. Notwithstanding the introduction of water from the new intake crib early in 1904, the typhoid death rate for the whole of that year was 48 per 100,000. It will be seen from the tables that in 1905 the typhoid death rate fell to 15 per 100,000, whereas prior to the improvement in the water supply it had, during the period covered by the table, never been lower than 20, and during 2 years of the 32 it had been below 30 per 100,000.

The Cleveland epidemic of 1903-04 covered a period of about 16 months, during which there were reported to the Health Department 4,578 cases of typhoid fever and 611 deaths. Mr. Whipple considers it probable that there were really as many as 7,000 cases, which would have been 1 for every 60 inhabitants. He considers that a conservative estimate of the financial loss to the city caused by the epidemic would be $3,000,000. On the basis of calculation used by Mr. Whipple in his paper entitled "The Value of Pure Water," in "Biological Studies," by the pupils of William T. Sedgwick (Chicago, 1906), the loss would have been double the sum named.

Some of the conclusions summarized by Mr. Whipple at the close of his paper have already been given. These may be noted as follows:

The water drawn from the new crib "is almost

*This paper, with discussions, will appear in the Journal of the New England Water-Works Association for September, 1906.

unpolluted by the sewage of the city, and may be considered at the present time as reasonably safe from the sanitary standpoint." Analyses and other evidence indicate that "under extreme meteorological conditions, such as may occur at infrequent intervals, it is possible that a slight and transitory infection of the new supply may occur." It should be noted that the low typhoid death rate of 15 per 100,000 in 1905 occurred during a year when the "meteorological conditions tending to promote pollution of the water" were unusually favorable. With the future growth of the city, the danger of pollution will increase, "until eventually the quality of the water may be affected by it to an appreciable extent"; so that, while the water from the new intake does not need filtration at present, "filtration will be imperatively necessary" before many years. The water, fortunately, can be easily purified by either slow sand or mechanical filtration. Such appreciable pollution of Lake Erie as exists in the vicinity is not due to other cities, so that "Cleveland alone is responsible for the poliution of her water supply."

TABLE I.—Population and Typhoid Fever Statistics, at Cleveland, O., 1873 to 1905.

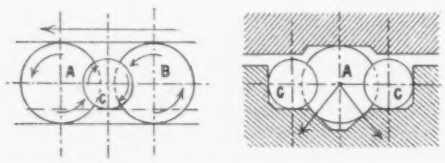
Year.	Estimated. Population	Total deaths.	Deaths from typhoid fever. Number.	Rate per 100,000	% all deaths.
1873	113,025	2,641	68	60	2.57
1874	119,757	2,190	81	68	3.70
1875	126,489	2,962	65	51	2.20
1876	133,221	....	65	49	...
1877	139,953	2,903	82	59	2.03
1878	146,685	2,710	55	38	2.03
1879	153,417	3,038	46	30	1.53
1880	160,146	3,156	70	44	2.21
1881	170,267	3,727	169	99	4.53
1882	180,388	3,156	122	68	3.87
1883	190,509	3,399	123	65	3.62
1884	200,630	3,732	121	60	3.24
1885	210,751	3,574	71	34	1.99
1886	220,872	3,525	113	56	3.20
1887	230,993	4,139	120	52	2.90
1888	241,114	4,414	113	47	2.56
1889	251,235	4,414	185	74	4.19
1890	261,353	5,058	180	69	3.56
1891	273,395	5,204	137	50	2.64
1892	285,437	5,227	167	59	3.20
1893	297,479	5,261	153	52	2.91
1894	309,521	5,663	89	29	1.57
1895	321,563	5,167	117	35	2.27
1896	333,605	4,859	143	43	2.92
1897	345,647	5,007	79	23	1.58
1898	357,689	5,040	121	34	2.40
1899	369,731	5,556	118	32	2.13
1900	381,765	6,104	205	54	3.36
1901*	392,400	5,834	140	36	2.40
1902*	403,032	6,134	133	33	2.17
1903*	414,950	6,799	472	114	6.94
1904	426,992	6,476	204	48	3.15
1905	439,034	6,190	74	15	1.24

TABLE II.—Number of Typhoid Fever Deaths in Cleveland, O., by Months, January, 1890, to June, 1905.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1890	16	55	11	7	14	24	14	21	21	21	10	10	180
1891	17	11	12	7	9	3	9	15	14	20	13	7	137
1892	7	3	12	5	8	18	29	27	22	21	12	3	167
1893	3	9	14	14	17	15	8	23	15	14	11	10	153
1894	9	6	8	4	1	4	7	14	4	12	12	7	89
1895	7	10	10	10	11	11	5	9	17	17	6	4	171
1896	5	10	19	15	14	10	13	15	16	6	11	9	143
1897	5	2	7	9	6	3	7	12	4	10	9	5	79
1898	6	8	3	5	10	11	6	6	4	21	9	22	121
1899	11	8	15	10	10	10	7	10	9	12	10	6	118
1900	7	14	29	33	22	10	12	27	15	14	8	14	205
1901	15	17	10	14	11	13	15	17	7	9	3	9	140
1902	14	12	12	6	16	13	12	9	11	8	12	8	133
1903	32	23	55	66	51	39	54	42	40	22	20	28	472
1904	12	46	53	28	10	10	5	5	11	12	7	5	204
1905	6	2	5	7	6	3							
Ave.	11	12	18	16	14	13	14	17	14	15	10	10	164

A NEW FORM OF BALL BEARING.

The principle of spacing the individual balls of a ball-bearing by means of a second set of balls which carry none of the load on the bearing but serve only as spacers, has been applied



Denis Ball-Bearing, with Two Rings of Spacing Balls.

in a new way by Mr. E. Denis, of St. Quentin, near Paris, France. Two sets of spacing balls are used, one on each side, and tracks are provided for them to bring them central with the larger main balls. The sketch herewith, taken from "Le Genie Civil," shows the arrangement so fully as to require no further explanation. This form of bearing has been applied to the step-bearings of centrifugal dryers.

THE CORROSION OF REINFORCING METAL IN CINDER-CONCRETE FLOORS.

Some examples of serious corrosion of the metal in reinforced concrete floors, made up of cinder concrete, were brought before the Structural Association of San Francisco some weeks ago by Mr. C. F. Wieland, C. E. After some discussion the subject was referred to a committee for investigation. The report of this committee was presented on Oct. 18. Through the courtesy of the Executive Committee of the Association we have been presented with an advance copy of this report and present it below in full:

To the Executive Committee of the Structural Association: At your request we have made an examination of the cases of corrosion of metal in cinder concrete floors, brought to your notice by Mr. C. F. Wieland.

We examined the specimens of floor slabs at Mr. Wieland's office and later each of us carefully examined the floors in the following buildings: Sloan Building—Post St.; age, 8 years; all floors cinder concrete and expanded metal on I-beams about 6 ft. apart. Crocker Estate Building—First and Mission Sts., the same construction; built in 1902. Rialto Building—New Montgomery and Mission Sts.; lower floor, same construction; upper floors, rock concrete and Johnson bars; built, 1902. Wells-Fargo Building—Second and Mission Sts.; built, 1894; cinder concrete and galvanized wire fabric; found the latter blackened upon the surface, but the metal was not corroded.

The cinder concrete is somewhat porous with occasional voids and also contains coal from dust up to lumps ¾-in. diameter. Rust spots occur in the concrete and where such spots are in contact with the metal, the corrosion is severe. The rust spots are sometimes an inch across, quite soft and easily removed by the finger nail. Occasional splinters of wood occur in the concrete, which shows that the heat was not severe as the wood is not charred. From the position of the floors it is certain that no water has reached the concrete since April 18, and that the corrosion was prior to the fire, but it appears to be more marked where floors have been exposed to the rains since the fire. The corrosion is irregular in amount. In some cases the expanded metal is only slightly rusted, and in places it is entirely destroyed, several places were noticed where a small semicircular patch had been removed from the edge of a metal strip; also at times it crossed the surface of the strip in a line, which suggests that it followed a surface crack in the metal. There seemed to be a tendency to corrosion at certain points in the diamond mesh, which would indicate that the metal had been strained in the process of setting and expanding, but there is not positive proof of this.

The extent of the corrosion is great enough to seriously endanger the safety of the floors, and it is not probable that the floors would have supported their loads more than one to three years longer.

CAUSES OF CORROSION.—Various reasons for the corrosion of metal in cinder concrete have been given. Prominent among them is the belief that it is due to sulphur in the cinders. In order to corrode metal the sulphur must first oxidize to H_2SO_4 and if there is any no able amount of cement present it would be absorbed by the cement. It is not probab'e that sulphur can corrode metal unless it is either close to it or the concrete is very deficient in cement.

Prof. Norton (see Report III., Ins. Exp. Sta., Boston) made several hundred experiments, and it is his opinion that the corrosion is not due to sulphur, but to a too dry mixture, which fails to properly coat the metal, and air and moisture enter the pores of the concrete and set up rusting action. This view is also confirmed by Booth, Garrett & Blair, who state that a cinder containing 0.2% of sulphur will not corrode steel, provided the concrete has sufficient cement mortar to close up the voids and cover the metal.

It is stated by makers of sheet metal pipe that there is a marked difference in the life of pipe that comes to San Francisco by rail or by sail. The exposure to a sea voyage renders the usual protection by dipping useless, as the surface rusts under the dip and the coating falls off the pipe. The pipe makers state that this happens to sheets apparently unaffected by rust when dipped. Slitting and expanding the metal sheets in manufacturing expande1 metal may cause minute cracks upon the surface of the metal. If this be combined, as in the case here, with a thin slab of concrete, porous and ranging in thickness from 2¾ to 4½ ins., with the metal in many cases flush with the bottom of the slab, there is an ideal condition for the rusting of the metal.

Hambuechen (Univ. Wis.) made a study of corrosion and has proved that a point of segregated carbon is always an initial point of corrosion, and has shown that burnishing steel or iron protects it, notably by removing the focal points; he has proved that rusting sets up a feeble current, the segregated carbon points acting as poles. Possibly the presence of much free coal and coke in the cinder may be a contributing cause by setting up feeble electric currents or by conveying them from earth currents due to leaks from trolley wires.

In the Rialto Building the upper floors are of sound rock concrete, and where the Johnson bars are exposed they are free of rust and appear to be in the same condition as when placed there.

The Bullock and Jones Building, a ten-story structure, had all its floors of rock concrete and expanded metal. During the repairs of the steel frame it was necessary to remove quite a number of floor panels and the metal was found in as good condition as when placed. The foreman who removed the floors told us that he had only observed two slightly rusted places, which rusting he thought had occurred prior to its being used in the floor.

PREVENTION.—Prof. Norton advises coating the metal with a paint of neat cement or dipping the metal in a thin grout. This is hardly a practicable method here, and it is doubtful if it could be done with that thoroughness that such work demands.

RECOMMENDATIONS.—That the Structural Association try to amend the present building law so as to exclude the use of cinder concrete in floor slabs or for fireproofing. That provision be made in the building law for the examination and tests of any existing cinder concrete now in use or that may be used at some later period.

(Signed) Luther Wagoner, Civil Engineer; Theodore H. Skinner, Architect.

San Francisco, Sept. 11, 1906.

APPENDICES.

I.

John B. Leonard, C. E.

Dear Mr. Leonard: I am off for Boston to-morrow so shall be unable to attend the next committee meeting. Please report that I examined the stone concrete in Wells-Fargo Building, reinforced with three different types of reinforcement in same slab; (1) Ransom bars, (2) ordinary galvanized iron chicken fencing, (3) galvanized iron ribbon grills, and found no rust of consequence on any of the three. The concrete was a dense mixture. The floors were about 8-ft. span, cored out to a thickness of 2½ ins., leaving ribs about 1 ft. c. to c., with a Ransom bar in each. The poultry net runs under the bars and follows closely the contour of the soffit of the slab; the ribbon mesh is placed near the top surface. I should think the construction must have been expensive, for in addition to the above there were Roebling suspended ceilings everywhere; but they did protect and no damage was done by fire to the floor slabs.

Yours truly, Theodore H. Skinner.

San Francisco, Sept. 22, 1906.

II.

Additional Notes on Cinder Concrete, by L. Wagoner.

Mr. R. Keatinge, the contractor on the Wells-Fargo Building, says that the cinder concrete contained small reddish brown rusty spots, about pea size. About two months after the floor slabs were laid, the rust spots probably swelled and forced off a cone of concrete about ¾-in. deep and 4 ins. diameter. No satisfactory explanation was found for this at the time. He also says the cinders were not clean.

Mr. Thos. W. Brooks, of the National Tube Co., San Francisco, quotes a number of cases of corrosion where pipes, both cast iron and steel, laid in cinder-filled streets in Pennsylvania, were destroyed in a short time. He says that this was so marked in the case of natural gas lines that they required a clay filling of at least 12 ins. to surround the pipe, where laid in cinder fills, to protect the same from pitting. From a book compiled by the National Tube Co. for their private use, a number of similar cases were noted. All of this seems to indicate free sulphuric acid in a very dilute form as the destructive cause.

The swelling of the pea-shaped rust spots above noted was probably due to additional oxidation with increase of volume. It is stated that iron produces ten time its volume of red rust, which would perhaps explain the forcing off of the cones of concrete mentioned by Mr. Keatinge.

III.

To the Executive Committee,
Structural Association of San Francisco.

Gentlemen: I append the following to the report of Messrs. Luther Wagoner, C. E., and Theodore H. Skinner, Architect, on the subject of "Corrosion of Metal in Existing Cinder Concrete Floors":

It has long been known that corrosion of iron and steel will result from its contact with coal or cinder. In response to my inquiry I have the following letter from Mr. W. H. Nisbet, National Steamship Co., Monadnock Building, San Francisco:

Replying to yours of 4th inst., I advise that in our practice (Thomas Cronin Co., Pittsburg), where cast or wrought pipe lines ran through cinder or ash piles, or roads constructed of either material, we completely sur-

rounded the pipe with gravel or rock concrete. The armor of concrete varied in thickness from 4 to 12 ins., dependent upon whether the excavation was through cinder entirely or earth mixed with cinder.

The reason why gravel or rock concrete should always be placed around pipe placed in cinder excavation is that, unprotected, the acids eat through the metal. In one borough in which we laid the entire water system, the distributing main ran through cinder for several squares. At the time we suggested to the water company that the pipe should be laid in concrete, but were told that so doing would entail an unnecessary expense. The result was that in eight months' time we were asked to replace that part of the system which had been laid direct in cinder, although the original pipe had been heavily coated with tar paint. This circumstance was due entirely to the action of the impurities in the cinder, for there were no underground wires nor street cars of any description in the place.

In Volume 23, "Transactions American Society of Mechanical Engineers," is a description of a "Steel and Concrete Coal Storage Plant" by Franklin M. Bowman, Structural Engineer, Riter-Conley Mfg. Co., Pittsburg. In Sections 6 and 7 thereof Mr. Bowman states:

Sec. 6. * * * it is important that the inside of the storage be entirely lined with concrete, so that no part of the supporting steel work is exposed to the corroding action of the coal.

Public attention has recently been called by Mr. Sooysmith to the possible danger due to corrosion in tall steel frame office buildings, but danger from this source is largely accentuated in a coal storage, with its sulphur and other corrosive substances. For this reason, where a permanent and costly structure is to be built, as usual in the case of large power-houses, coal bins lined with steel plates should not be used, as they are liable in time to become a menace to life and property.

Sec. 7. In the case of Lowell, all main columns, and as far as possible the intermediate columns, are entirely covered with concrete. * * * The essential point is to have the steel framework, and especially the joints, entirely surrounded and imbedded in concrete, as under these circumstances the steel will not corrode.

The use of cinder aggregate, in coal-burning districts, encourages itself by the fact that it can usually be obtained free of cost. Then, too, its advocates contend that the lightness of weight of a cinder concrete slab makes it possible to design a supporting structure of lighter members. Common sense should forbid the use of a substance which can be crushed to powder under foot, and makers of reinforcement should eliminate from their trade literature all data in reference to cinder concrete, and thus free themselves from all moral responsibility which is implied in the giving of data involving its use. The relative strength of cinder concrete slabs to rock concrete floor slabs of equal thickness is as ½ to 1, a fact which is also against the use of cinder concrete.

That the poultry netting in use in the Wells-Fargo Building is not more visibly corroded is doubtless due to the fact that in the process by which wire is successively drawn to its final gage from the rod, a skin is given it which ensures it a longer life than rolled sheet metal subsequently sheared. Some specimens I have of the netting in question show corrosion. Rolled sheets may have the same physical and chemical characteristics as possessed by the rod out of which the wire for poultry netting is drawn, but the subsequent shearing surely lays bare the "vitals" of the sheet to more ready attack by the elements of corrosion than would be the case with the frequently drawn wire. I contend against the use of any iron or steel in contact with cinder concrete; and I believe it no easy task to find cinder free of coal and other corrosive elements.

Mr. Keatinge having mentioned the blowing which took place in the cinder concrete in the Wells-Fargo Building, it is interesting to cite the experience of like character touched on by Mr. C. Newton Russell, Borough Electrical Engineer, Metropolitan Borough of Shoreditch, London, in his paper on "Refuse Destruction by Burning, and the Utilization of Heat Generated," in "Transactions Amer. Soc. Mech. Engineers," Vol. 25, 1904. In the refuse which finds its way out of domestic kitchens, iron and steel in the shape of pins, small screws, tinned plate scraps, etc., is of course met with, and in the sorting, such as done in some plants for the destruction of garbage, cannot be recovered. In paragraph 28 of Mr. Newton's paper he speaks of the use of the clinker, resulting from the refuse destruction, in the making of road and sidewalk slabs, but without indicating that metal reinforcement was employed by Mr. E. J. Lovegrove, Borough Engineer to the Horsey Borough Council, London, in the slabs. Mr. Newton states:

Mr. Lovegrove had also used the material for plastering and rendering to a somewhat large extent; but, while it made a very hard plaster, there was one defect which showed itself to a greater or less extent, namely, that after the plastering or rendering had been finished for a few months, signs of blowing had occurred, causing small circular flaws about ¼ to ½-in. in diameter in the face of the plaster. On examining these they appeared to be due to minute particles of iron in the clinker. In cases where this occurred the small pieces were cut out and made good, and no further trouble was experienced.

I feel that the purpose of the investigation into "Corrosion of Metals in Existing Cinder Concrete Floors" will have been served when such reinforced floors in all parts of the land have been cut into and inspected and the use of cinder concrete in connection with any kind of steel and iron be prohibited in all building ordinances.

C. F. Wieland, C. E.

Oct. 9, 1906.

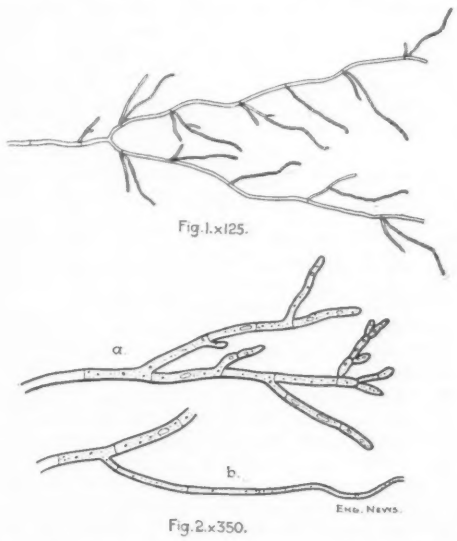
FUNGUS GROWTH ON EXPERIMENTAL PERCOLATING SEWAGE FILTERS AT WATERBURY, CONN.

By Leo F. Rettger.*

The writer's attention was called recently to a peculiar condition of sewage filters which on extended inquiry was found to be of rare occurrence. For the immediate facts concerned the writer is indebeted to Mr. Wm. Gavin Taylor, Resident Engineer, and Mr. H. B. Hommon, Chemist, of the Waterbury sewage disposal works.

During the past year the city of Waterbury installed an experimental sewage filtration plant consisting of settling tank, septic tank, contact bed, slow sand and rapid stone filters.

The rapid filters were constructed of crushed trap rock. The size of the pieces was such that they would pass through a 2¼-in. ring and be held back by a 1¾-in. ring. The diameter of each filter was 7 ft. 5⅜ ins., and the depth 5 ft. The area was 1/1000 acre. The sewage was distributed over the beds in the form of a spray. The filtration ordinarily went on at a rapid rate and the effluent attained a high degree of purity.



Figs. 1 and 2. Fungus Growths on Experimental Sewage Filters, Waterbury, Conn.

Although the filter beds were exposed to the direct rays of the sun, a slimy vegetable growth soon made its appearance on the surface. When left undisturbed for several days, and particularly during cloudy weather, this growth spread rapidly over the top of the filter. It covered the exposed surfaces of the crushed stone and to a large extent filled up the more superficial interstices. The layer easily acquired a thickness of 0.5 to 1 cm. (— 0.4-in.), and, as a natural consequence, the rate of filtration was greatly reduced. In fact, the obstruction became so great at times that the water remained standing in small pools.

The color of the slimy mass varied from a pale or salmon pink to almost jet black. The reddish color was, beyond a doubt, due to iron. After washing for a long time in running water, the mud-colored portions became almost colorless, with here and there a patch of pink. On teasing out minute particles of the growth under water, I soon found that it consisted of a compact mass of muscle-like fibers or filaments which had every appearance of being a mold. Microscopic examination further strengthened this view.

It was impossible to free the fibers from all the bacteria which adhered to them, so that plate cultivation and isolation of the mold were at first quite difficult. This was accomplished, however, by the use of acid sugar gelatin. The composition of this medium is as follows: water, 1,000 cu. cm.; gold label gelatin (acid), 120 grams (12%); dextrose or lactose, 30 grams (3%). The natural acidity of the gelatin, which was sufficient to turn blue litmus paper decidedly red, was left unchanged.

For inoculation purposes, 10 cu. cm. of the liquefied gelatin were poured into a sterile Petri dish. After the gelatin had solidified, small fragments of the well-washed mold were drawn over the surface of the medium between the points of fine pincers. The plates were kept at about 20° C. in a dark place.

The mold grew luxuriantly, so that within 36 hrs. distinct or continuous colonies were quite apparent along the inoculation streaks. They rapidly grew in size, attaining a diameter of 3 or 4 mm. by the fourth or fifth day. The colonies were colorless and decidedly fuzzy. On microscopic examination they were seen to be made up of numerous long, fine filaments radiating from the center.

In the older colonies the filaments had many branches, and cross-walls could be seen at frequent intervals. The fruiting organs were a peculiar feature. They were small oval bodies which were attached end to end, a single "sausage chain" containing as many as thirty or forty of them. These chains had their attachment at or near the crosswalls, and in the axillary parts of the fungus. (Fig. 1.)

Bacterial colonies made their appearance very slowly on the acid gelatin, so that the isolation of the mold could be accomplished easily.

Pure transplantations were made in ordinary gelatin, agar and bouillon. Good growths were obtained in each of these media, though not as luxuriant as when grown on the acid sugar gelatin. In bouillon a surface pellicle was formed, if left undisturbed. In the pellicle the mold had about the same appearance as on solid media. If disturbed, however, the subsequent bottom growth was entirely different. The threads were short and thick, and the fruiting bodies (if such they were) in a large measure resembled elongated yeast cells. On inoculating sugar gelatin plates with this material, the above-mentioned characteristic colonies were again obtained.

In 12% gelatin prepared from the crude sewage (sewage + gelatin) very delicate growths occurred; hence this medium was soon discarded.

The morphology of the organism in question varies still more than has just been indicated. With few exceptions the filaments in the original growth were much thicker than in the gelatin colonies. The former were more or less plasmolyzed also, and the fruiting bodies were much fewer and to a considerable extent resembled those seen in the depths of bouillon cultures. (See Fig. 2a.) They seemed to be nothing more than constricted portions of the fungus branches.

That the growths observed in the coating of the stone filter and in the gelatin plates were one and the same organism was particularly well shown by the fact that here and there in the filter growth long slender branches of the gelatin colony type were seen which grew out from the coarser filaments. (See Fig. 2b.)

The fungus in question grows well at incubator temperature, but far less luxuriantly than at 22 to 25° C. It also thrives, for a while at least, under anaerobic conditions, though contact with atmospheric oxygen is far more favorable.

While I have been unable to identify the organism with any degree of certainty, it may be said that it closely resembles Monilia in most particulars. This is the opinion also of a botanist (colleague) who has had considerable experience with fungi.

Just a few words regarding the character of the sewage as it entered the filters. It was distinctly alkaline, and contained about 35 parts of alkali per 1,000,000 when read in terms of calcium carbonate. The crude sewage pumped at the station was very fresh. During the winter and spring, the putrefactive action in the septic tanks was not nearly as strong as in the summer months.

The operators in charge have made extended experiments to eliminate the fungus growth from the filter beds. The most successful of these was the following: The beds were allowed to re-

*Assistant Professor of Bacteriology and Hygiene, Sheffield Scientific School, Yale University, New Haven, Conn.

main at rest for a day or longer, until the surface growth had dried down to about the thickness of a sheet of tissue paper. The upper portion of the beds was then vigorously stirred with a stout pick or rake. Immediately following this the filters were washed with a strong hose stream of city water until the effluent became fairly clear. In this process large quantities of black suspended matter were removed, and the beds were rid of the filter "parasite." Quite satisfactory results were obtained, also, by allowing the filters to rest a peroid of two days out of seven and washing out the scaly fungus residue by merely turning on the spray and resuming the filtration process.

THE CONSTRUCTION OF SAND-CLAY AND BURNT-CLAY ROADS.*

Neither sand alone nor clay alone, as every one who has traveled over country highways knows, makes satisfactory roads; but by properly combining the two materials, and providing good drainage and proper crowns, satisfactory results can be obtained. An interesting discussion of ways and means for obtaining such results is given by Mr. William L. Spoon, Road Expert, U. S. Department of Agriculture, in Bulletin No. 27, Office of Public Roads. In addition, there is a brief account, illustrated by half-tone views, of the construction of burnt-clay roads. The use of burnt clay for a variety of purposes, we may interpolate, is extensively practised in England, where gravel and suitable material for broken stone are often not easily obtained. In this country the nearest precedent is the use of burned clay for railway ballast.

Clays for use for road making are divided by the author into slaking and non-slaking, the slaking clays falling to pieces when immersed in water, much "as a lump of quicklime will do under similar conditions." Slaking clays, though more easily mixed than the more plastic clays, are often of inferior binding power.

In mixing sand and clay for road material, the aim should be to completely fill the voids in the sand with clay. When this is done, a few inches of the mixture "will bear comparatively heavy traffic for a long time, even when the subsoil is sand or clay." Experiments by the Office of Public Roads indicate that the sand and clay should be thoroughly mixed and puddled with water; the method employed being of little consequence so long as a thorough mixing is secured.

Obviously, where a choice can be had, it is better to haul the clay than the sand to the road. It is advisable to begin placing the clay at the end of the road nearest the clay bed, so that all the clay placed will have the advantage of being worked by the succeeding loads. For single-track roadways it has been found advisable to distribute the clay over a width of about 12 ft. and to a depth of about 6 to 8 ins. in the center, tapering to a thin layer at either side. After the clay is spread it is covered with a layer of clean sand. If the clay is plastic, or lumpy, alternate plowing and harrowing may be necessary in order to effect thorough disintegration. After rains it may be advantageous to continue the harrowing. If the road shows a tendency to ball or cake, more sand should be added, and if it loosens in dry weather it may be concluded that the clay lacks binding power. Where particularly favorable materials are available, the ordinary traffic may be relied upon to work the clay and sand, but good results are always hastened by the use of plow and harrow. A final crowning and smoothing should be given by a road machine, and after this a light coat of sand may be added.

For an average depth of 6 ins. of clay 12 ft. wide, 1 cu. yd. of clay would be required to cover 4½ lin. ft. of road, or 1,173 cu. yds. per mile.

The foregoing remarks relate to the construction of sand-clay roads upon a sandy base. Where a clay subsoil exists, the road surface should slope from the center to the sides at the rate of at least ½-in. per ft. Further details of construction are described in the bulletin as follows:

> The foundation having been properly prepared, the surface should be plowed and harrowed to a depth of about 4 ins. until it is pulverized as completely as possible. It is then covered with 6 to 8 ins. of clean, angular sand. The sand should be spread so that the layer is thickest at the center of the road, following in general the same plan as was outlined for spreading clay upon a sandy foundation. The first mixing by plow and harrow is now done while the materials are still in a comparatively dry state. It has been found that the clay foundation can be more evenly disintegrated when in this condition. After this first mixing has been finished the road is finally puddled with a harrow after a rain. In case an excess of clay works to the surface and tends to make the mixture sticky, sand is applied until this trouble is overcome.
>
> Upon the completion of the mixing and puddling, the road should be shaped while it is still soft enough to be properly finished with a scraper and at the same time stiff enough to pack well under the roller or under the action of traffic. In case it is impossible to obtain the proper consistency of the surface material, it is better to shape the road when somewhat too wet than when it is too dry, even if it is necessary to stop traffic upon it for a few days. The road should be opened to traffic as soon as practicable after completion, as this will be found to have a beneficial effect upon it.

The approximate cost per mile of 12-ft. sand-clay road on sand, the applied material having a depth of 6 ins., is given as follows:

Crowning and shaping road with road machine, using two teams at $3 and one operator at $1.50 per day for one day	$7.50
Loosening 1,173⅓ cu. yds. of clay with pick and shoveling into wagons, at 15 cts. per cu. yd.	176.00
Hauling 1,173⅓ cu. yds. of clay, at 23 cts. per cu. yd.	269.86
Spreading clay with road machine, using two teams at $3 and expert operator at $1.50 per day for three days	22.50
Shoveling sand on clay, estimated at ½ ct. per sq. yd.	35.20
Plowing, using one team at $3 per day for four days	12.00
Harrowing, using one team at $3 per day for two days	6.00
Shaping and dressing with road machine, using two teams at $3 and expert operator at $1.50 per day for two days	15.00
Rolling, estimated at ½ ct. per sq. yd.	35.20
Total	$579.26

The sum total given is equivalent to about 8 cts. per sq. yd. Construction on a clay foundation, the bulletin states, would cost about the same.

The actual cost of sand-clay construction in the South has ranged from $200 to $1,200 per mile, and generally from $300 to $800. Two roads built under the direction of the Office of Public Roads cost as follows: Gainesville, Fla., 1 mile long, 14 ft. wide, 9 ins. depth, $881 per mile, or 10 cts. per sq. yd.; Tallahassee, Fla., 16 ft. wide, about 7 ins. deep, $470 per mile, or about 5 cts. per sq. yd. It appears from the bulletin that these figures do not include any grading.

After laboratory experiments with "gumbo," or sticky clay from the Yazoo District of Mississippi, it was decided to build an experimental piece of burned-clay road in the State named. The gumbo clay and some of the essential points in its preparation and use are described in the bulletin as follows:

> Gumbo clay is black, owing to the high percentage of organic or vegetable matter it contains. It is particularly sticky in its nature, and is almost wholly free from sand and grit. After it has been burned, however, the plasticity is entirely destroyed, and a light clinker is formed which, though not particularly hard, when pulverized forms a smooth surface and seems to wear well. It should be understood that not all of the clay out of which the road is to be constructed is to be clinkered, but only a sufficient amount should be rendered non-plastic to neutralize the too sticky character of the native clay. Fortunately the gumbo district is plentifully covered with heavy timber, thus affording an abundance of fuel.

In preparing the roadbed for burning the clay, the first step is to plow deeply, using four horses or mules. Transverse furrows or ditches 4 ft. apart are then dug, extending 2 ft. beyond the finished roadway on either side. Cord wood is then laid at right angles to the cross-ditches, forming flues for firing. More wood is then put on, but in the other direction so as to build up a cribwork. In the spaces left in the cribwork, lumps of clay are piled, care being taken that the lumps are large enough to allow for a draft. Above the clay thus placed, more wood is laid parallel to the first layer, clay put on, and a third layer of wood added. A top layer of clay 6 to 8 ins. deep is placed, tamped and rounded off, after which the hole is ready for firing. When available, coal slack may be substituted for the two upper layers of wood.

After the firing has been completed, both the clay added and that in the ridges should be burned thoroughly, forming a layer of burnt clay 10 to 12 ins. deep. This layer is reduced by rolling to a depth of 6 to 8 ins. Before rolling, "the roadbed should be brought to a high crown," preferably by a grader.

The cost of 300 ft. of experimental road at Clarksdale, Miss., was as follows:

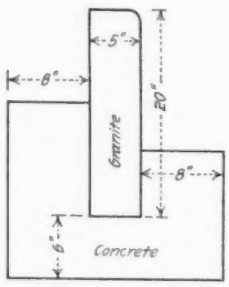
30½ cords of wood at $1.30 per cord	$39.65
20 loads of bark, chips, etc	6.00
Labor at $1.25 per day and teams at $3 per day.	38.30
Total cost of 300 ft	$83.95
Total cost per mile at this rate	1,478.40

Since this stretch of experimental road was built, numerous sections of similar road have been constructed in the same locality, "and up to the present time only favorable reports regarding them have been received."

TWO REMARKABLE EXAMPLES OF CONCRETE IN TENSION AT DULUTH, MINN.

By B. C. E.

This year in Duluth has shown concrete in tension by accident on two occasions: (1) The failure of an old, dry wall allowed the earth to drop away from a length of curbing, so that the concrete in which the curb was bedded had to sustain its own weight and that of the granite curb for a clear span of 42 ft. The curbstones were from 4½ ft. to 7 ft. in length, bedded in concrete, as shown by the accompanying sketch.



The concrete was composed of 3 sacks of Portland cement, ½-yd. of bank sand and to 1 cu. yd. of gravel: that is, it was 1 : 4 : 8, loose measure. It was placed in November, 1905, with frosty nights, and the curb was left self-supporting as stated, in April, 1906, when the frost came out, causing the old, dry wall to fail. The curb in concrete hung as a beam several days, until it received a lateral blow.

(2) Another case, this year, of concrete standing tension was caused by an unexplained cave-in, in a street paved in 1903 with asphalt. The section was a foundation course of natural cement concrete, 5 ins. thick, a 1-in. binder course and 2 ins. of asphalt wearing course. The concrete foundation was laid in May, 1903, and was composed of 3 sacks natural cement to ½-yd. sand, ½-yd. gravel and ½-yd. crushed granite, or a 1 : 2 : 4 mixture. The cement used (neat) had a strength of 70 lbs. per sq. in. at seven days.

A slight depression appeared in the spring of 1906, in the return of an intersection, and became nearly 3 ins. deep by the last of September—carrying a moderate traffic all the time, including loads of 2,000 lbs. per wheel in the course of paving the intersecting avenue. Also a three-wheel steam roller with a weight of three tons per each 18-in. rear wheel passed over the depression several times, and a steam roller having a weight of four tons on each rear 20-in. wheel passed one wheel over the center of the depression at least twice.

On breaking up the pavement and foundation a hole was found, knee-deep and roughly rectangular, 5.3 ft. × 6.3 ft. In bringing the bottom up to the sub-grade, 2¼ cu. yds. of rock, besides the broken concrete, was used. The unit stress in this concrete of so low a grade must have been 300 or 400 lbs. per sq. in., if not more, for at one end was the header that settled with the pavement; and the suspended curb must have induced a unit stress in the 1 : 4 : 8 Portland cement concrete of at least 400 lbs. per sq. in., although it had been frozen 5 of the 5½ months of its life.

I submit this not as an argument for the use of concrete in tension, but as an argument for the use of concrete in bedding curb and for street foundations.

*See also paper on "Economical Methods of Road Improvement in the South," by Chas. H. Scott, C. E.; Engineering News, March 27, 1902, p. 200.

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A Committee of the Structural Association of San Francisco has recommended that the use of cinder concrete in floor construction should be forbidden in municipal building ordinances. We publish the report of this committee in full in this issue, and it will undoubtedly receive the careful attention of engineers interested in any department of structural work. The committee examined several buildings having cinder concrete floors, and found such serious corrosion, in one case at least, that, in the opinion of the committee, "it is not probable that the floors would have supported their loads more than one to three years longer."

When reinforced concrete first began to be extensively used, there were many doubts expressed as to the life of steel embedded in concrete. If we may judge from general practice at the present time, those doubts have been generally set at rest. Experiment and experience have pretty well established that iron or steel embedded in good Portland cement concrete is permanently preserved from corrosion.

Many engineers, however, after they had been convinced of the durability of reinforced concrete in situations protected from the weather still remained skeptical as to the life of iron or steel embedded in concrete which was exposed to the weather, or immersed in water or in sea water. If these skeptics still persist, however, none appears to listen to their prophecies. Vast sums of money are to-day being invested in structures whose safety will be imperiled and whose life limited, if any mistake should be made as to the life of steel embedded in concrete and then exposed to water or moisture.

Similarly, many engineers were skeptical originally, as to the use of cinder concrete in floor construction. Iron or steel embedded in coal ashes is pretty sure to be rapidly corroded. It was natural therefore to doubt that the mixing of these ashes with cement mortar could neutralize all corrosive tendency. Practice and experience appears to indicate, however, that in most cases steel reinforcement in cinder concrete is not attacked by rust. That this immunity cannot always be relied upon, however, the experience in San Francisco appears to show. As to what influences cause the steel to be corroded in one case and eaten away in another, the profession is still in the dark. It may be reasonably conjectured that ash from coals containing an excessive amount of pyrites will be more liable to cause corrosion, and also that cinder concrete exposed to moisture, as in the floor of a factory where wet processes are carried on, will be more likely to cause corrosion than concrete kept dry, as in an office building. But this does not answer the question: "Can this particular batch of cinders be safely used for a concrete floor without risk of its eating up the steel reinforcement?" We doubt if anyone is wise enough at present to furnish an answer.

As noted above, the San Francisco committee proposes to avoid all risk by forbidding entirely the use of cinder concrete. But is there not something to be said on the other side of this question? Cinder concrete has a very real and practical advantage in its lighter weight, and another advantage on which stress is laid by many engineers in its greater resistance to fire. There may be places where the fire risk might justify the use of cinder concrete in preference to stone concrete even if gradual corrosion of the reinforcement were a foregone certainty. In the present state of our knowledge, therefore, it seems premature to forbid by law the use of cinder concrete.

It may be remarked in this connection that the material which goes into cinder concrete is as almost as varied in character as the material from which the cinders are derived, and in nine cases out of ten this material is a good deal short of what any competent engineer would regard as ideal.

There is a real demand for a material for concrete aggregate which shall be at once light in weight, reasonably strong, stable in structure, chemically inert, and last but by no means least, low in cost. Hard clinkers from boiler furnaces are probably as near an approach to this as is now commercially available; but something better may yet be brought forward. Blast furnace slag might perhaps be made use of for the purpose if produced without free sulphur and of stable structure. An ideal material would be volcanic pumice stone, vast quantities of which are said to exist in Mexico and other volcanic countries; but the cheap transportation problem would have to be solved to make this commercially available.

One of the largest, most interesting and most promising sewage works in the world is that which treats the sewage of the 900,000 people living in and near Birmingham, England. The creative genius of these works, Mr. John D. Watson, M. Inst. C. E., is known throughout Great Britain and America for his extended studies of the general subject of sewage disposal and his practical application of those studies to the Birmingham works. Mr. Watson has written a number of notable papers on the subject which he has mastered so well. To the most recent of these, read early in September, 1906, we give a large amount of space elsewhere in this issue. We need call no further attention to the paper, except to note its general breadth of tone and its wealth of suggestions regarding the design of percolating filters and accessory settling tanks.

Probably ninety per cent. of the specifications for stone masonry which make any pretension to completeness contain the following requirement: "All stones shall be laid on their natural bed."

A contributor in this issue calls attention to the fact that the "natural bed," or the way the stone lies in the quarry, does not always coincide with the "rift" of the stone, or the direction in which it splits most easily. Again the extensive use of the channeling machine in stone quarrying brings into the market stone which is cut without regard to the plane of easiest cleavage.

It is probably a fact that in most specifications the "natural bed" requirement is merely put in by the engineer because it is customary, and neither he nor the contractor pays any attention to it. There are a few cases, however, such as the capstones under bridge pedestals, where it is really of prime importance that the stone shall be laid with its faces parallel with the rift of the quarry; and in such situations attention to the method by which the stone has been quarried is worth while.

The worst bridge accident that has been recorded for a long time took place at a small deck drawbridge on the Pennsylvania Railroad's newly equipped line from Camden, N. J., to Atlantic City on Sunday, Oct. 28. An electric train of three cars was derailed at the drawbridge and plunged over the side into deep water, causing the death of 64 persons, mostly by drowning. The first two cars were entirely submerged. The rear end of the third car remained out of the water resting on the cribbing under the drawbridge. The speed at the time of derailment appears to have been low, not more than 20 miles per hour, probably. A stop had been made at Pleasantville, only a short distance back. The draw had been opened about 20 minutes before to permit a boat to pass, and a northbound train had passed over the bridge on the other track before the southbound train which was derailed. A statement issued by the Pennsylvania R. R. officials declares that the drawbridge was found properly closed and locked, with the signals showing clear and that "the track was in good condition." The condition of the equipment will not be known until it can be raised from the water; but the cars were all new, having been put in service with the opening of the new electric line in September.

The derailment occurred at the entrance to the drawspan. The outer rail on the drawspan after the disaster was found bent inward over a foot toward the center of the track. Further, the end of this rail had the *outer* side of its head cut and worn away, almost certainly by the impact of the successive wheel flanges. The evidence thus presented is almost absolute that when the ill-fated train came along, this rail was out of place sufficiently for the wheel flanges to strike against the end of the rail-head cutting it away to its present shape. The wheels then dropped off the rails, swerved gradually toward the outside of the bridge as they ran along over the ties and finally struck and climbed the outer guard timber at a point about 150 ft. from the end of the drawspan.

Doubtless the first question raised in the mind of an engineer studying the story of this accident is whether the bridge floor was properly protected by guard timbers and guard rails, to guide derailed wheels and prevent them from swerving sideways off the bridge. In answer to this question it is to be said that so far as our present information goes, the bridge had outside guard timbers *but no inside guard rails.*

We believe that this fact ought to be indelibly impressed on the mind of every engineer and every railway officer as the main and most important lesson to be learned from this terrible accident. How the train came to be derailed at this particular point is of comparatively small interest. There is always a chance of derailment in railway operation from one cause or another; and where derailment means such great danger as it does on any bridge structure, both outside and inside guard rails should be provided to hold derailed wheels in line.

It was the contention of the late A. M. Wellington that a bridge with outside guard timbers and no inside guard rails is more dangerous than it would be if the outside guard timbers were left off. The reason for this is that a derailed truck which strikes an outside guard timber is almost inevitably swerved still further out of line, and so skewed that it is certain to climb the guard timber. The inside guard rail, on the other hand, guides the backs of the opposite wheels and holds them closely in line. This is not mere theory, but has been proved in many cases where derailed wheels have been carried safely over bridges. The Atlantic City wreck, on the other hand, illustrates how a derailed truck will run along over the ties until it strikes the outer guard timber and thus receives a fatal skew that sends it over the side of the bridge.

THE CONSTRUCTION OF IRRIGATION WORKS BY THE U. S. RECLAMATION SERVICE.

A new era in irrigation was marked by the opening of the large works known as the Truckee-Carson Project of the United States Reclamation Service, described in our issue of Oct. 18. These works, when completed, will be not only the largest of the kind ever built in this country, but they are one of a large number of projects now under construction or being planned by the Government. They are of the utmost importance, also, as laying great emphasis on the fundamental principle of success in irrigation: that the ownership of land and water should never be separated.

A combination of causes seriously retarded the development of irrigation works in the United States in the last decade of the 19th century. The failure through a variety of reasons of irrigation companies, and the friction often existing between such companies and the land settlers and water users, led to the development of the irrigation district idea, upon which great expectations were based. The so-called "Wright Act" passed by the California Legislature in 1887 provided for the creation of large irrigation districts for the development of irrigation works at the expense of property owners. These districts were in many respects like municipal corporations, but, although some forty of them were formed in a few years and millions of dollars raised by bond issues were expended, the results obtained were in most instances disastrous to all concerned, unless it were unscrupulous speculators, contractors and public officials. The underlying object of these irrigation districts was sound, but, as well stated by Mr. Elwood Mead, M. Am. Soc. C. E., in his "Irrigation Institutions," men who previously had never spent as much as $500 of their own money at one time were suddenly entrusted with the expenditure of hundreds of thousands. Under such circumstances it was not surprising that funds disappeared like snow beneath the warm sun, and coincidentally the opposition of the large land owners increased as the years and the money went. All land owners, it may be explained, were taxed proportionately to the value of their holdings for the works carried out by the irrigation districts, but each owner had only one vote regardless of the area of his holdings. The district law was intended in part to discourage large holdings of land, but its more fundamental as well as righteous object was to provide for ownership of water developments by those who owned the land and used the water. Subsequent trials of the irrigation district plan in other States, profiting by the experience in California, have, we believe, proved more successful. But neither these local districts nor the schemes contemplated and in a few instances carried out under the Carey Act (mentioned again below) met all the demands for irrigation works in the Far West, particularly where works of great size, involving immense expenditures of money and many years of time in construction, are necessary.

Some of the causes contributing to the failure of the early irrigation companies (it should be understood that not all these companies were failures) were their speculative character and their frequent neglect to secure proper engineering advice. In addition, they did not always obtain, and in many instances it was next to impossible for them to secure, sufficient rainfall and stream flow and other data necessary for the proper design and operation of their works. But one of the greatest causes of the downfall, or at best the moderate success, of many of the companies was their effort to secure proprietary and perpetual control of the water, without which land taken up by the settlers was valueless. This attempt, with its accompanying friction between the companies and the settlers, and the burdens upon the latter, wrecked or dwarfed many enterprises that might otherwise have proven highly remunerative to the companies and of great benefit to the settlers.

The beginning of better days in the irrigable district of the West was when the U. S. Geological Survey entered upon its surveys of possible reservoir sites for storing water for irrigation, and also and particularly when it began its stream gagings in the same portions of the country. By these means, data were gathered which were useful and necessary to the most intelligent and profitable irrigation development, and at the same time a group of active, forceful men, mostly young men, gained a familiarity with many of the sections in greatest need of irrigation and with the streams that could best be made available for supplying them with water.

The Carey Act, passed by Congress in the early '90's, turned over to such of the arid States as accepted its provisions 1,000,000 acres, each, of the public domain. The States taking these lands agreed to see that irrigation works were built to supply them with water and that the lands were settled, all under conditions intended to protect the settlers against rapacious land grabbers and speculators in water rights. In fact, so far as the water rights were concerned, the great principle already mentioned—namely, that the water necessary to irrigate the land should go with the land—was provided in the Act. A number of States immediately passed the necessary legislation for the acceptance and development of grants under the Carey Act, and some of these States, particularly Wyoming and Idaho, have secured the construction of important irrigation works by private corporations. But these developments involving, as they did, the investment of private capital for a term of years, and also involving contracts between the corporations and the settlers (the contracts, of course, providing for the acquisition of water rights, or really joint ownership in irrigation works by the settlers), it was necessary for capitalists to get back all their original investment, with interest, within the period provided for the payment for water by the settlers, and in addition a profit on the construction and operation of such irrigation works as they built. Although the settlers under the Carey Act buy their land from the State at a nominal figure and are guaranteed ultimate joint ownership of the irrigation works under State supervision, yet there attach to this plan some of the objections, even though chiefly sentimental, that pertain to the acquisition of such a necessity as water from a private company. Moreover, many, if not the majority, of the most economically promising irrigation possibilities awaiting execution involve huge expenditures for immense dams and storage reservoirs and for large and lengthy main canals and hundreds of miles of distributaries. The magnitude of these works and expenditures, combined with other causes that cannot be discussed here, has prevented the highest desirable development of irrigation works under the terms of the Carey Act.

After many years of occasional and chance agitation for the construction of irrigation works by the National Government, followed by an educational campaign in the East as well as the West on behalf of the importance of further irrigation development of the whole nation, and with the impetus given by the powerful and intelligent support of President Roosevelt, Congress passed an act (signed June 17, 1902), which made possible the extensive irrigation works now under construction by the National Government. Under this act the proceeds of the sale of public lands are pooled in a fund which is made available for reclaiming land under the direction of the Secretary of the Interior. The accumulation of funds under this act has been more rapid than was expected, there now being some $30,000,000 available or in sight for early use. To the growth from the sale of lands there is now beginning to be added a return to the original fund through the instalments being paid to the Government by settlers for the payment for their respective shares of the irrigation works constructed to water the land taken up for settlement under the various projects.

The character and extent of the work being carried out by the United States Reclamation Service has been described in considerable detail in Engineering News, particularly in our issues of Nov. 26, 1903, and June 15 and July 20, 1905 In other issues we have described, with the aid of contract drawings and specifications, parts or the whole of four irrigation projects about to be executed at the time the articles were published.* Over ten pages of our issue of Oct. 18, 1906, were devoted to a description of the Truckee-Carson irrigation project, which was put in partial operation on June 17, 1905, just three years after the signing by President Roosevelt of the act making this and other similar works possible. The Truckee-Carson project, in point of inception and first application of water to land, ranks as the pioneer. The article just mentioned was prepared by one of the engineers of the United States Reclamation Service, who for many years has contributed to this journal articles on engineering work in the Far West.

As has been indicated, and as most of our readers know, the Truckee-Carson project is only one of many large irrigation works now under construction, each involving an expenditure ranging from hundreds of thousands to some millions of dollars. The outlay contemplated for the present on the Truckee-Carson project is about $3,500,000, which, it is expected, will make possible the irrigation of some 200,000 acres of land. Ultimately, however, this project will entail the expenditure of some $9,000,000 and will provide a water supply sufficient to irrigate 350,000 acres.

Obviously a great force of Government engineers is employed on these many large irrigation works. The basis of this large engineering corps is formed largely from the hydrographers of the United States Geological Survey who have been measuring the flows of streams in the West. These men, however, were neither sufficient in numbers or experience to carry on all the work in hand, and they have been reinforced, both as to numbers and experience, by men drawn from all parts of the country; but naturally Western men with experience in irrigation, or if not in irrigation then in water power and other Western developments, have been engaged so far as feasible. There has been some tendency on the part of engineers in the West, outside of the Service, to criticize the engineering staff on these Government irrigation works, but on the whole a large proportion of the best engineers in private practice in the West appear to think that the Reclamation Service, under the remarkably able leadership of Mr. F. H. Newell, M. Am. Soc. C. E., as Chief Engineer, has been both judicious and fortunate in the selection of its engineering staff.

The growing scarcity of labor in the West is an increasing source of embarrassment to some of the contractors on the various works of the Reclamation Service. From reports that have reached us, it appears that a large proportion of the contractors are not making much money, while some are perhaps losing, on these irrigation contracts. For these and doubtless for other good reasons there seems to be a tendency on the part of the Reclamation Service to have more and more of its work done on the percentage basis. Presumably this tendency will be strengthened by the factors indicated, and also by the notable example set by the Panama Canal Commission in its recent invitation for the construction of the Panama Canal on a percentage basis, as noted in our issues of Oct. 11 and 18.

Although not pertaining directly to engineering, brief mention may be made of the plan under which the settlers are to acquire water ownership under the various irrigation projects. The land will be taken up in the usual way that arable public domains have been acquired by settlers. Ownership in water will be acquired by the payment to the Government of the actual cost of construction and an estimated cost of operation of the irrigation works. Each settler will be restricted as to the area of the land which he can take up, the actual area depending upon the nature of the land and whether or not all of it will be irrigated or some of it utilized, say, for grazing purposes. In any event, the area will be small compared with even some of the fair-sized farms in the East, to say nothing of

*Jan. 12, 1905; Feb. 9, 1905; Aug. 10, 1905 (Under "Investigation of Stresses in High Masonry Dams"); Feb. 22, 1906.

the corn and wheat lands of the West. The cost of constructing and operating the irrigation works will be distributed pro rata, according to acreage, and the total will be payable in ten equal annual instalments, without interest. Obviously the price per acre will vary with local conditions pertaining to the several projects; but it was expected, when a member of the editorial staff of this journal visited the Truckee-Carson project shortly before water was turned on in 1905, that the cost to settlers there would be considerably under $30 an acre. If $30 be taken as a round sum, it will be seen that the annual payment would be only $3 an acre for all the water necessary to irrigate it; and this with no interest charges and no assessments for maintenance. It is quite likely that some variations from the general plan outlined will be found necessary as time goes on. Ordinary maintenance charges, however, may be expected to be relatively small, in view of the permanent character of all the construction, practically no wood being used except for certain minor purposes. Moreover, it should be remembered that, in notable contrast with many private irrigation companies, the Reclamation Service is to deliver water on to each settler's land; so that in addition to his yearly charge he will not be called upon to maintain or help maintain ditches connecting the main works with his land.

The success of the irrigation works built by the U. S. Reclamation Service, from an agricultural point of view, is more definitely assured than would have been the case some years ago by the experimental and other work in the application of water to land carried out by the U. S. Department of Agriculture under the direction of Mr. Elwood Mead, M. Am. Soc. C. E., Chief of Irrigation Investigations.

We venture to express a hope that these large Government irrigation enterprises will have a salutary effect upon private irrigation in general, both as object lessons in construction and as laying further stress upon the prime importance of eliminating water rights litigation from irrigation practice in the West.

The next great step in making available large areas of now worthless land on the part of the Government will perhaps be the carrying out of drainage works. Several bills looking to investigations of drainage possibilities were recently introduced in Congress. Mr. Mead and his assistant in charge of drainage investigations, Mr. C. G. Elliott, M. Am. Soc. C. E., have been making drainage studies for some years past, and it has been reported that the Reclamation Service will make some extensive surveys of lands needing reclamation. Once having launched upon irrigation enterprises, and those enterprises giving every promise of success, it is likely to be difficult for the Government to refuse the demands for aid in the reclamation of the millions of acres of swamp and overflowed lands along the Atlantic Coast and the swamp lands in the Central West. Those who worked so many years for irrigation plead that it was quite as legitimate for the Federal Government to spend money in irrigation works as on rivers and harbors, and now it may be expected that the drainage interests will cite the expenditures for both the improvement of navigation and for irrigation, in support of their claims. We cannot at this time enter into a discussion of the advisability of the Government undertaking drainage works, but the subject deserves serious consideration.

Added point is given to the foregoing paragraph by a call for a "national congress of drainage interests," just received. The call has been issued by the Governor of Oklahoma (Hon. Frank Frantz). The date set for the proposed congress is Dec. 5 to 7, 1906, and the place is Oklahoma City, Okla. The Chamber of Commerce of the city named urges as a precedent for this drainage movement the organized effort in behalf of the national irrigation development, to which we have referred already. It is also urged that systematic drainage work would be of direct benefit to every State in the Union. We hope that the congress will be attended by representative men from the East as well as from the West.

LETTERS TO THE EDITOR.

Shipping Cement in Bulk for the Welland Canal Works.

Sir: In reference to the article in your issue of Oct. 11, "Why not ship cement in bulk?"

Between the years 1880 and 1888, nearly all the cement used on the New Welland Canal Works at Welland and Port Colborne was shipped in bulk in small barges decked over. About 15,000 barrels was thus shipped and gave satisfaction; the distance was 12 and 20 miles, respectively. A portion was shipped in cars in bulk also.

Yours truly,

W. L. Leslie,
Dept. Railways and Canals.

Ottawa, Canada, Oct. 22, 1906.

Rules for the Crown Thickness of Arches.

Sir: Referring to the editorial on page 437, of your October 25th issue, relative to the reinforced concrete conduit (arch) 32 ft. in clear span inside and 20 ft. in height, with a crown thickness of only 8 ins., we are reminded by some misguided people that engineering is an exact science.

I have taken the trouble to refer to the work of Dr. Hermann Scheffler, on the "Theory of Arches," and find that he gives on p. 241, for an arch of 30-ft. span, under an embankment 100 ft. high, a crown thickness of 5 ft. and a thickness at the spring line of 8 ft. (approximate.)

There seems to be a wide difference in the "theory" of the two engineers.

Yours truly,

Emile Low, M. Am. Soc. C. E.

Rome, N. Y., Oct. 26, 1906.

Reinforced Concrete Buildings in Japan.

Sir: In trying a ferro-concrete building in Japan, we experienced the following difficulties: 1. A thin wall, 3½ ins. thick, exposed to the sun (Japanese summer heat 80°-95° Fahr. in shade), conducts heat, and is warmed on its inside face, which is disagreeable. 2. Such thin walls exposed to extremes of temperatures are liable to show fine cracks due to expansion and contraction.

Are not these troubles unavoidable with very thin curtain-like walls, no matter how careful the execution? If so, what should be the minimum thickness to avoid them? I remain,

Yours truly,

N. Shiraishi, C. E.

Kobe Branch Mitsu Bishi Company, Kobe, Japan, Sept. 15, 1906.

[We should think the best way to avoid the difficulties named would be to use hollow walls of concrete blocks. A thick, solid wall would be more apt to show expansion cracks when exposed to hot sun than a thin wall.—Ed.]

Regarding the Formation of a Danish-Norwegian Engineers' Club in New York City.

Sir. I see by Engineering News (Oct. 11, p. 390) that a Scandinavian Engineers' Society has been founded at Dresden, Germany, by students of the German technical schools and engineers of that city, and that branches are to be formed in the United States; also that Scandinavian engineers everywhere are requested to become members.

Anyone looking into this matter will, I am sure, readily see the complications which will naturally arise by taking in as members, engineers not graduated from these schools, and I believe it a mistake to encourage such a society here, and suggest that an engineers' society, composed of Danes and Norwegians, be established on the same basis as the Swedish Engineers' Club of Brooklyn. I do not see why a Danish-Norwegian club should not be able to prosper in New York City. There are many Norwegian and Danish engineers in the city and vicinity who do not belong to any engineering society, and I am sure these would gladly join such a society as noted above.

If Norwegian and Danish engineers who are interested in this matter will send me their names and addresses, we will arrange a meeting for discussing the project.

Yours truly,

Edmund Mackenzie.

551 45th St., Brooklyn, N. Y., Oct. 22, 1906.

A Method of Alining Railway Tangents, When Preparing for Ballast.

Sir: As I have seen no reply to the query of A. B. in your issue of Sept. 6, p. 256, I will outline my method of handling tangents, when preparing for ballast, hoping that it may be of use to him and others.

For this work I endeavor to get my tangents as near a straight line between P. I.'s as possible. To accomplish this, I set up the transit near a curve point and get the line of track, as near as possible, and then produce that line to the next P. I. In doing this, I get the general line of the track and then locate two points, 500 ft. or 1,000 ft. apart, according to the clearness of the atmosphere and the perfectness of the object glass in the transit. I next set the transit over the second point and back sight on the first, after which I locate a third point the same distance forward of the former, as the former is ahead of the latter, and reverse on it with great care. I continue to produce this line forward in this manner to a point near the P. C. of the next curve, and, at each point located I measure the distance to the right hand rail and record it. When this is done I can, by inspection, tell whether I have the line that best fits the track. If not, I can tell, with a very little simple calculation, at just which point to swing my line to secure the best line to fit the track, as it is on the ground, the idea being to get a straight tangent that will fit the track as it is on the ground and save as much relining as possible. When the line is decided on, I next calculate how much each point, already set, has to be moved, to get it on the line that I have selected and measure them in, using a tape graduated to hundredths. I then set over alternate points on the selected line and run each way by foresights, in this way getting a line that is as near a straight line as can be run, and, at the same time, reducing the trackwork to a minimum.

On the curves I get the intersection points, either by running the tangents to their intersection, or by running in long chords and calculating the curve point if the P. I. is hard to get at. After establishing the curve points, I run in the curve and establish, at first, only temporary points. I then measure and record the distance from the temporary points to the outside rail at each station, after which, by calculating the external for the curve at the given degree, and for another curve either one minute more or one minute less, I can tell whether I can better the curve by flatteing or by sharpening it, having in view all the time the reduction of trackwork.

This method makes work for the instrumentman, but the time of a party of three is less valuable than that of a track gang of 50 to 100 men.

Yours truly,

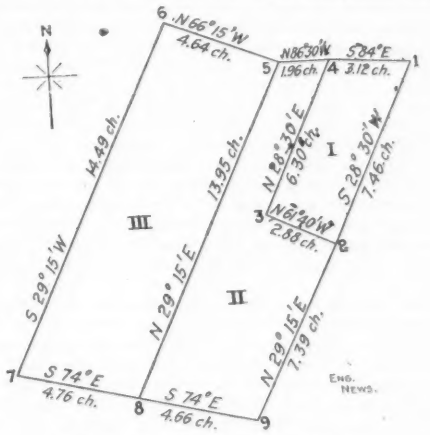
R. A. Rutledge,
Resident Engineer, Gulf, Colorado & Santa Fe Ry.

Beaumont, Texas, Oct. 13, 1906.

Adjusting the Survey Record of Three Contiguous Lots.

Sir: I recently struck a problem in surveying which seemed to me to permit of a number of solutions, none of which is satisfactory. If space permits, I would be glad to have you submit the problem to the surveyor fraternity, of which the majority seems to be represented in your circle of readers.

A piece of land, roughly rectangular in shape and containing some 13 acres, is composed of three lots, originally described by metes and bounds in at least two different deeds 80 to 100 years old, which descriptions were



Sketch of Three Contiguous Lots.

brought together in a single deed 25 to 30 years ago. By the lengths and bearings given, none of the three lots closes, and the errors of closure are uncomfortably large. The problem before me is to adjust the bearings and distances to make the three surveys close. This can be done by arbitrary guess, but there ought to be a more scientific way. I have nearly reached the conclusion that an arbitrary-guess adjustment will be as good as any.

From the early date of the description (which I suppose was taken from a survey record), I judge that there is much more likelihood of errors in bearing than of errors in distance. An adjustment wholly in bearings would therefore have some probability in its favor.

I am sure that a resurvey is needed, and it may be that by assuming the corners, from existing fence-lines, hedge-rows, stone-piles, etc., a delimitation of the land could be obtained which would have better legal value than any involving some use of the old description. But

whether this be true or not, the present problem, a problem in theoretical and practical surveying, is the adjustment of the old metes and bounds.

Herewith is a scale sketch of the land, giving lengths and bearings. I have translated the lengths, given in chains and links, into feet in the following table, in which I also give the latitudes and departures of the several courses.

LATITUDES AND DEPARTURES OF COURSES.

Course.	Bearing.	Length, ft.	Latitude, ft. (N plus.)	Departure, ft. (W plus.)
Lot I.:				
1—2	S 28° 30'W	492.36	—432.696	+234.934
2—3	N 61° 40'W	190.08	+ 90.212	+167.308
3—4	N 28° 30' E	415.80	+365.413	—198.403
4—1	S 84°E	205.92	— 21.525	—204.792
			+ 1.404	— 0.953
Lot II.:				
2—3	.....	.....	+ 90.212	+167.308
3—4	.....	.....	+365.413	—198.403
4—5	N 86° 30'W	129.36	+ 7.897	+129.118
5—8	S 29° 15'W	920.70	—803.302	+449.872
8—9	S 74° E	307.56	— 84.776	—295.645
9—2	N 29° 15' E	487.74	+425.548	—238.320
			+ 0.992	+ 13.930
Lot III.:				
5—8	.....	.....	—803.302	+449.872
8—7	N 74° W	314.16	+ 86.595	+301.989
7—6	N 29° 15' E	956.34	+834.397	—467.287
6—5	S 66° 15' E	306.24	—123.335	—280.305
			— 5.645	+ 4.269

Yours truly, "Old Deed."

Concerning Charges to Contractors in Filing Bids and Executing Bonds.

Sir: In the matter of contracts it is only right that both parties should be considered as being mutually benefited. The consideration named indicates that each party is willing to give the other some valuable thing, and therefore neither is benefited more than the other. This being the case, it is not in accord with fairness that the one that has something to buy should impose all the onerous conditions on the one who has something to sell or some work to do. In the case of dealing with private individuals, the contractor would insist on having some of the features more in his favor or refuse to enter into the contract. With municipalities, however, it is often necessary to submit to apparently unreasonable conditions in order to have the proposal considered. This is notably the case with the City of Philadelphia. The contractor first finds that in addition to filing with his bid a proposal bond he must also accompany it with a certificate from the city's law department (charge by the city, $2) that a bond for $500 has been deposited with the Department of Law. A certified check will not answer in lieu of this certificate. The bidder must also agree to "enter into a contract in a form to be approved by the City Solicitor." Suppose he secures a contract amounting to $100,000. He is furnished by the law department with a contract and two bonds for his signature and those of his bondsmen. To these is bound the specifications, which are made a part of the contract. The documents themselves are for the most part a printed form, and the few written words they contain could be written in five minutes. For this he is charged $30, of which $20 is for the contract and $5 for each bond. When he asks that, for his own protection, the contract be executed in duplicate, he is told that it is not the custom and cannot be done. His only copy is a typewritten one, which he must have made at his own expense, and then the law department refuses to certify that it is a correct copy. Total amount paid to the city's law department, $32.

Now, such a small cost on a contract of that amount is inconsiderable and would not be objected to by the contractor if he could feel that he was getting duplicate copies for his own guidance and protection, but he naturally dislikes to pay for documents which belong to the city, which go no further than their own filing cases and which should properly be made at their own expense.

The writer has made contracts with many municipalities, and, while a general disposition is shown to have everything in favor of one side, in no case except that of Philadelphia, has he been obliged to contribute to the city's support of its law department.

Yours truly.

"Contractor."

Philadelphia, Pa., Oct. 22, 1906.

[It ought to be clear enough to anyone that all the expense to which the contractor is put will have, in the end, to be paid by the party for whom he works. In this case the city taxpayers. If his bidding expenses average 5% of the cost of the work done, then he must add 5% to his bidding price over and above his ordinary profits, to meet these expenses.

Of course, if the fee for these legal documents is assessed for the benefit of and is actually paid into the city treasury, no one is the loser. We strongly suspect, however, that investigation would show these fees finding a final resting place in the city's legal department. They constitute probably an extra perquisite in addition to the salaries. Petty graft of this sort in Governmental affairs is very hard to root out. It is too small a matter to attract much attention. The contractor finds little fault, as he desires to stand well with the city legal department and can unload the burden on the taxpayers anyway. The taxpayers are under the delusion that the contractor pays the fee out of his own pocket; and suppose that the more risk and expense can be loaded on the contractor, the better off the public will be. We wonder whether if contractors were treated with something like a square deal in letting contracts, there might not be less temptation to graft in their execution.—Ed.]

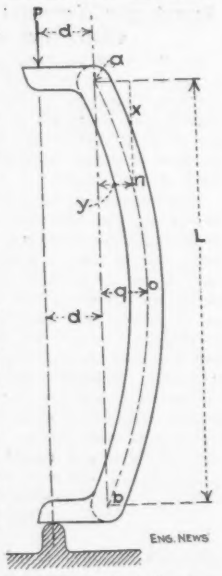
Further Discussion on the Analysis of Columns.

Sir: In reply to the criticisms of my analysis of the stresses in long columns, and a proposed method of design for the same, I beg to say:

First. Your comment following my letter in the Sept. 6 issue rather misrepresented my views in one important particular, where you state that I propose to use the nominal safe working stress of the material, namely, 15,000 lbs. in the case of soft steel, as the working stress in a long column. In the case of a soft steel having a commercial elastic limit of 35,000 lbs., it is probable that an appreciable proportion of the material will have a true elastic limit but little in excess of 30,000 lbs. per sq. in. Columns built of such material would therefore fail at 30,000 lbs. unit stress, if designed on the principles I advocated. The factor of safety of 2 is obviously insufficient, when we remember that it has to take care not only of all accidental overloads, but also temperature stresses, defects in material and workmanship, etc. The factor should be not less than 2½, or preferably 3, for dead loads, and 4 for live loads. Accordingly, I would advocate the use of 10,000 lbs. per sq. in. as the working stress in long columns carrying a dead load, and of 7,500 lbs. in the case of a live load, when such columns are designed by my method, and constructed of steel having a true elastic limit of 30,000 lbs. per sq. in.

By true elastic limit I mean that stress at which the deformation of the material ceases to be strictly proportional to the stress. By commercial elastic limit, I mean that stress at which the beam of the testing machine drops, or "hangs" for a minute, due to the sudden yielding of the material.

Second. In reply to Prof. Church I would say that his criticism of my figure is entirely correct, and that the one he proposes is the one I had in mind. The oversight on my part was due to the fact that the theory of the matter considers only the upper half of the column.



Third. Prof. Church's argument that the form of the elastic curve of the column is different for the two systems of loading when each produces the same deflection, and that therefore the moments produced by the eccentric load P, and Euler's critical load W, centrally applied, are unequal, is correct. The treatment which I adopted in deriving my formula is that outlined on p. 217 of Merriman's "Mechanics of Materials," for eccentrically loaded columns. Prof. Merriman repudiates this work on a subsequent page, and it is difficult to see why it finds a place in his book. The error consists in assuming that since either the assigned eccentric load P, or Euler's critical load W, will produce the same deflection (Euler's load will produce any assigned deflection), that therefore their moments are equal. As a matter of fact they do not have the same moment, as Prof. Church's consideration of the elastic curve shows. This does not, however, render my formulas or my conclusions incorrect, as will appear from the following.

The moment of the load P about the dangerous section at the center of the eccentrically loaded column is inversely proportional to the radius of curvature of the elastic curve at that point. In like manner, the moment of W at the same section of the centrally loaded column is inversely as the radius of curvature at that point. Since in general the two elastic curves will be different, the radii of curvature, and therefore the moments will be different. As the eccentricity d approaches zero, however, the form of the two curves for the same deflection q, approaches equality, so that in the limit, which is the only case that the derivation of my theory is concerned with, the radii of curvature, and therefore the moments, become equal. For this reason, my results instead of being rudely approximate, as Prof. Church intimates, are on the contrary theoretically exact.

Fourth. To clinch the matter, I beg to offer the following perfectly rigorous derivation of my theory. It is strictly analogous to the derivation of Euler's formula given in Prof. Church's "Mechanics of Engineering," p. 364, and is based on the common theory of flexure.

Taking the case of a round-ended column with an eccentric load P, as shown in the figure herewith (a reproduction of Prof. Church's Fig. 2, in Eng. News, Sept. 27, 1906, p. 336), we will assume the middle of the length as an origin, with the X-axis vertical. The moment of the stress couple in any section n may be written $E\,I\,d^2y/dx^2$. The moment of the external forces about this section is $P\,(d+q-y)$. Then by the principles of Mechanics,

$$E\,I\,\frac{d^2y}{dx^2} = P\,(d+q-y) \qquad (1)$$

Multiplying each side by dy we have

$$\frac{E\,I}{dx^2}\,dy\,d^2y = P\,(d+q-y)\,dy \qquad (2)$$

Integrating between the limits $y = 0$ and $y = y$, and the corresponding limits $dy = 0$ and $dy = dy$, we have

$$\frac{E\,I}{dx^2}\int_0^{dy}(dy)\,d(dy) = P\,(d+q)\int_0^{y}dy - P\int_0^{y}y\,dy \qquad (3)$$

or

$$\frac{E\,I}{dx^2}\times\frac{dy^2}{2} = P\,(d+q)\,y - P\,\frac{y^2}{2} \qquad (4)$$

Solving for dx we get

$$dx = \sqrt{\frac{E\,I}{P}}\times\frac{dy}{\sqrt{2\,(d+q)\,y - y^2}} \qquad (5)$$

We may put this in the form

$$dx = \sqrt{\frac{E\,I}{P}}\times\frac{d\left(\frac{y}{d+q}\right)}{\sqrt{2\frac{y}{(d+q)} - \left(\frac{y}{d+q}\right)^2}} \qquad (6)$$

by dividing both sides of the fractional factor by $(d+q)$.

Integrating between the limits $x = 0$ and $x = x$, and the corresponding limits $y = 0$ and $y = y$, we have

$$\int_0^{x}dx = \sqrt{\frac{E\,I}{P}}\times\int_0^{y}\frac{d\left(\frac{y}{d+q}\right)}{\sqrt{2\frac{y}{(d+q)} - \left(\frac{y}{d+q}\right)^2}} \qquad (7)$$

or

$$x = \sqrt{\frac{E\,I}{P}}\times \text{vsin}^{-1}\left(\frac{y}{d+q}\right) \qquad (8)$$

Now when $x = \frac{1}{2}\,l$, then $y = q$.

$$\therefore\ \frac{l}{2} = \sqrt{\frac{E\,I}{P}}\left[\text{vsin}^{-1}\left(\frac{q}{d+q}\right)\right] \qquad (9)$$

solving this expression for q,

$$\text{vsin}^{-1}\left(\frac{q}{d+q}\right) = \frac{l}{2}\sqrt{\frac{P}{E\,I}} \qquad (10)$$

$$\frac{q}{d+q} = \text{vsin}\,\frac{l}{2}\sqrt{\frac{P}{E\,I}} \qquad (11)$$

$$q = \frac{\left(\text{vsin}\,\frac{l}{2}\sqrt{\frac{P}{E\,I}}\right)d}{1 - \left(\text{vsin}\,\frac{l}{2}\sqrt{\frac{P}{E\,I}}\right)} \qquad (12)$$

An inspection of this equation shows that when the eccentricity of the load, d, is indefinitely small, the deflection q is also indefinitely small, unless the expression $\left(\text{vsin}\,\frac{l}{2}\sqrt{\frac{P}{E\,I}}\right)$ becomes equal to 1, in which case q becomes indefinitely large (indeterminate—Ed.). The expression $\left(\text{vsin}\,\frac{l}{2}\sqrt{\frac{P}{E\,I}}\right)$ becomes equal to 1 when $P = \pi^2\,E\,I \div l^2$.

The maximum fiber stress in the column will be found by the formula

$$f = \frac{P}{A} + \frac{P\,(d+q)}{Z} \qquad (13)$$

where f is the maximum stress, and Z is the modulus of the section. If d approach zero as a limit, the right-hand term will vanish, unless P becomes equal to $E\,I\,\pi^2/l^2$, in which case it becomes infinite (indeterminate—Ed.). Therefore, if a column be subject to a load P, having an indefinitely small eccentricity, d, the maximum fiber stress produced by the load is $f = P/A$, unless $P = E\,I\,\pi^2/l^2$.

in which case the column fails, since the right-hand term becomes infinite (indeterminate—Ed.).

That P shall not exceed the limiting value, we have the relation

$$r^2 = \frac{f\,l^2}{E\,\pi^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (14)$$

We can not increase f beyond the elastic limit of the material, since if we do, E is very much reduced, being no longer a constant. Hence if f in equation (14) be taken as the elastic limit of the material of which the column is composed, the expression gives the value of the minimum radius of gyration which the column should have. If the radius of gyration is made greater than the value indicated, the strength of the column will not be appreciably increased, but if it be reduced from this point, the column will be weakened very much, so that if the radius of gyration be reduced to half its former value, the strength of the column will be reduced three-fourths.

While Prof. Church's consideration of the matter is purely theoretical, and tends to confirm my views, Mr. Ross attacks the practical side of the question. All of Mr. Ross' contentions are based upon the fact that in practical work the load is not absolutely central, but somewhat eccentric and therefore that the column would fail at some less load than my theory would indicate. I would say in answer that since we design columns with a factor of safety to cover this very point, it is as well covered by the use of a theory that is correct as by one which is not. Or perhaps we might adopt the theoretically more correct method of assuming a probable eccentricity for the load, and then designing our column. The two methods would not, however, give sufficiently different results to warrant the use of the more correct but laborious one.

This matter is not, however, as serious as Mr. Ross' statements would lead us to believe. Although the load is never central, it is never in good modern practice very far from central, unless special provision is made. I doubt very much if there are many columns whose load has an eccentricity of 25% of the radius of gyration, in which case for a solid circle I compute that the total stress due to both compression and flexure are still amply covered by the factor of safety.

Taking Mr. Ross' points in their order:

1. As has already been shown, the "flexure moment," W q, becomes indefinitely small for an indefinitely small eccentricity of the load. Therefore Mr. Ross' statements that it alters the distribution of the stress and weakens the column are both untrue.

2. His second point is true, but I do not see that it has any particular bearing on the point at issue.

3. This point is also well taken, provided we are to consider imperfections of material and workmanship. We do not, however, generally consider them in developing a theory.

4. His statement that for ordinary values of I, L, (load, I presume), and r ÷ l, the effects of lateral deflection and direct compression will appear together is untrue if the column be centrally loaded, since there will be no lateral deflection.

Finally, if we take the case of a small but finite eccentricity of the load, we will find that it takes a load equal to one-half Euler's load in order to produce a deflection equal to the eccentricity, and that therefore the effect of the flexure in adding to the stresses in the column is so small as to be amply covered by the factor of safety.

Thanking you for your space, and your correspondents for their criticisms, I am,

Very truly yours.

Forrest E. Cardullo.

Syracuse University, Syracuse, N. Y., Sept. 29, 1906.

[The previous letter of our correspondent made this recommendation: In designing a column, fix the radius of gyration by the use of a formula given in the letter, and then, to find the required area of cross-section,

use the expression A = P/f, where A is the area required, P is the axial load, and f is the *safe working stress of the material.*

Note the italicized words. The column is to be loaded to the safe working stress of the material, not to any reduced stress determined by a column formula. This is precisely what our note stated, except that we used actual figures for illustration. The factor of safety, and whether ultimate strength or elastic limit is to be reckoned from, are matters not concerned in the present question. But if Mr. Cardullo advocates 10,000 lbs. unit stress for "long columns," and if he would use a higher unit-stress for simple compression, then he unconsciously repudiates his own devices; for, to make a "column-reduction" by adopting a higher factor of safety is just as effective a way as to apply Euler's or Gordon's or anybody else's formula.

It seems necessary, in view of the numerous equations and incidental mathematics in both Mr. Cardullo's and Prof. Church's letters, to point out that these have no essential connection with the real proposal which Mr. Cardullo makes. The recommended procedure for design follows direct from Euler's formula, by the application of the reasoning used in the last three paragraphs of Mr. Cardullo's first letter (Sept. 6, p. 262). The determination of the effect of eccentricity of loading has nothing to do with the matter, and operates to conceal the actual derivation. If an overscrupulous conscience suggests that a perfectly straight "long column," centrally loaded, can never deflect because there is nothing to start a deflection, it will only be necessary to assume an infinitesimally small eccentricity, or in other words to recognize the fact that columns in real life are not perfect but always have sufficient error in straightness and sufficient departure from purely central loading to start a deflection when the Euler limit is approached.—Ed.]

Notes and Queries.

In order to give credit where it is due, it should be stated that the rapid work in the building and erection of the steel frame for the new buildings of the Kennedy Valve Mfg. Co., of Elmira, N. Y., (illustrated on p. 428 of our last issue), was done by the Elmira plant of the American Bridge Co., under direction of Mr. Lewis, the Resident Manager.

THE COLORADO RIVER was turned into its original channel, by the Southern Pacific Engineers' Corps, Oct. 24, according to press dispatches, after having flowed into Salton Sea for about two years (Eng. News, Feb. 22, 1906, p. 216). The feat was accomplished by building a concrete dam, supplemented by a rock and gravel dam, across the break in the river bed.

AN EXPLOSION OF NATURAL GAS at Coffeyville, Kan., Oct. 28, demolished five 2-story brick buildings, killed two persons and injured twenty-four others, four seriously. The gas is said to have leaked into the buildings from a defective main.

SEVEN MEN WERE KILLED and two others injured by an explosion in the Rolling Mill Mine of the Cambria Steel Co., at Johnstown, Pa., Oct. 24. The explosion, which occurred in a heading about three miles from the mouth of the shaft, did not damage the workings, and is said to have been due to gas fired by a blast.

A SHORT CIRCUIT of feed wires in a conduit at Atlantic and Third Aves., Brooklyn, N. Y., Oct. 29, tied up nine lines of the Brooklyn Rapid Transit System during the morning rush hour. An explosion, which threw manhole covers skyward, followed the short circuit.

WET LEAVES caused a suburban electric car, on the Chagrin Falls line of the Eastern Ohio Traction Co.'s system, to skid down a steep hill at Chagrin Falls, Ohio, Oct. 24. The momentum of the car was so great, when it reached the bottom of the hill, that it jumped the track at a sharp turn and turned over, injuring eight passengers.

A HURRICANE off Coto Island, Japan, Oct. 28, destroyed 228 fishing vessels and drowned some 822 men.

REPORTS OF THE GULF STORM LOSS just received from Mr. R. W. Carter, Bridge Engineer, who is stationed at Jew Fish Creek, 45 miles south of Miami, Fla., indicate that practically no damage was done to the Florida East Coast Ry. structures and embankments by the hurricane of Oct. 18. At the Long Key Viaduct the concrete was uninjured, though the cofferdams about the unfinished piers were destroyed. Between Long Key and Upper Matecumbe, some of the unfinished fill was washed away, but the loss was slight.

THE SCARCITY OF PIG IRON in the Pittsburg district has become so great that $23 is being asked for first-quarter foundry, and the situation is rapidly becoming worse. Companies have been forced in several cases to take Southern pig, but owing to a serious shortage of cars in Alabama there is not much of this in sight. It is estimated that the blast furnaces must run at the rate of 27,000,000 tons per year in order to alleviate the pig iron scarcity by the end of the present year. They are now producing at the rate of 25,000,000 tons per year.

THE PROPOSED ELEVATED RAILWAY LOOP, to connect on the New York side the bridges over the East River between New York and Brooklyn, has been voted down by the New York Rapid Transit Commission, 3 to 3, Mayor McClellan not voting. The Chief Engineer of the Commission, Mr. George S. Rice, M. Am. Soc. C. E., has been instructed to prepare plans for a subway to serve the same purpose as the proposed loop, but it is reported as doubtful whether or not the plans when prepared will be adopted by the Commission.

THE CHICAGO STREET RAILWAY CONTROVERSY, which has been in progress for some years between the city and the railway companies, bids fair to reach a settlement. After conferences between representatives of the city and the company, a "general settlement ordinance" has been tentatively agreed upon, and it is said that the provisions of this ordinance meet the approval of Mayor Dunne. The proposed ordinance is published in full in the Chicago "Chronicle" of Oct. 26, and presumably in other Chicago papers of that date. As it is yet subject to amendment, only its general features may be mentioned here. The ordinance provides for general reconstruction of the whole street railway system of the city, now virtually owned by two companies; this reconstruction to include a subway loop in the heart of the city. Under the ordinance the city would have the right to buy out the companies on the 1st of January of each year, by giving notice six months prior thereto. In event of purchase, the city would pay a sum for the present property, to be fixed by mutual agreement, as we understand it, before the proposed reconstruction is effected, and in addition it would pay the cost of the contemplated improvement. The city would also share in the net profits of the company. The ordinance provides for a board of three supervising engineers, one to be named in the ordinance and the other two to be chosen, one by the city and the other by the companies. A single fare, with transfers, is provided for under a contemplated agreement between the two systems, now operated separately.

THE FIRST EXPOSITION OF SAFETY DEVICES in this country will be held January 28 to February 7 in the Museum of Natural History, New York City. The safety devices to be exhibited are for safeguarding the lives of working men and women, and for preventing accidents under the ordinary conditions of life and labor to which the general public is exposed. They include the personal equipment of workers in building trades; protective devices for boilers, water gages, signal apparatus, boiler and pipe valves; protective devices for electrical machinery and acetylene apparatus; devices for turning on power and shutting it off; fire protection, and the prevention of explosions; first aid to the injured; storing of explosives; safety devices for metal-working machinery; safety devices for paper-cutting, stamping and molding machinery; safety appliances for elevators and hoisting apparatus; workingmen's dwellings; ventilation; cooking; safety appliances for agricultural machinery; and safety devices for hand and circular saws, planing machinery, etc. Other expositions of this nature have been held in Europe and in Canada, and as an outgrowth of them several Museums of Security have been organized—one at Vienna in 1890, one at Amsterdam in 1893, one at Munich in 1900, one at Berlin in 1901, and one at Paris in 1905. Statistics show that of the same number of men employed in a given trade, there are in America from two to nine times as many accidents as in European countries. The purpose of the exposition is to educate the American public regarding the present situation in these matters and the means of its improvement. The interest of manufacturers generally is solicited as well as that of organizations for improving the conditions of labor. Dr. William H. Tolman, 287 Fourth Ave., New York City, should be consulted regarding space for exhibits.

ELECTRIC HEATING FROM PEAT has been proposed for Brockton, Mass., by the Peat Fuel & Heating Co., of that city. It is intended to erect a plant on one of the peat bogs near the city and generate electricity so cheaply that heating and cooking by means of the current will be less expensive than with coal. The company proposes first, however, to manufacture peat for sale as a fuel. There is a company about to start along these lines in Norwood, but the Brockton company will be the second to employ machinery for treating peat to make it available as commercial fuel.

THE NEW SOUTH WALES RAILWAYS AND TRAMWAYS are turning out very successfully, according to the Railway Commissioners' report for the year ending June 30, 1906. The combined earnings are about $25,000,000; this is an increase of over $2,500,000 for the railways and about $280,000 for the tramways, over the preceding year. The increase was well divided among practically all classes of traffic. General live stock and wool amounted to about $1,000,000, while passengers helped to increase the earnings by about $600,000. The expenditure after making a liberal allowance for the general up-keep of the property and renewals, shows an increase of about

$580,000. The details show that considerable rolling stock was rebuilt out of the working expenses, and after paying the working expenses and the interest on the capital, the commissioners report a surplus of about $2,200,000. The tramways show an equally satisfactory result. The earnings were about $4,200,000, the expenses about $3,325,000, and after paying working expenses and interest, there was a surplus of about $275,000 The tramway traffic was well maintained throughout the year, the number of passengers carried being 145,000,000. The mileage opened was 126, the greater portion being worked by electric power. Besides the routes through the city of Sydney, the Railway Commissioners control the tramway system at Newcastle, Broken Hill, Parramatta, and the outlying suburbs of Sydney. All lines in connection with Sydney are now worked electrically, covering 139 miles of single track. Outlying suburban and country lines are worked by steam over 42½ miles of single track and by horses over 1¼ miles. An experiment was made with steam motor omnibuses, but after six months' trial the scheme was given up as unsuccessful. The Government of the State is about to appoint for the New South Wales Railways and Tramways, a chief commissioner, with salary at the rate of £3,000 a year; an assistant railway commissioner at a salary of £1,500 per year, and a tramway commissioner at £1,500 a year. Appointments in each case are for a term of seven years, and particulars regarding them may be obtained from R. W. Cameron & Co., 23 South William St., New York.

A FOUR-MASTED SCHOONER equipped with a 500-HP. gasoline engine was launched Oct. 18 from the yard of Cobb, Butler & Co., Rockland, Me. The schooner has a gross tonnage of 2,047, and is 242 ft. long. The engine is guaranteed to give a speed of six knots an hour in a calm. An electric generator is also installed for operating an electric hoist. The schooner is owned by the Northern Maine Power Packet Co., and is intended to carry paper, coal, and agricultural products.

THE TANTALUM LAMP is now offered to the retail customers of the New York Edison Co. in a circular sent out with the monthly bills, at the net price of 35 cts. Whereas the company furnishes free renewals of the ordinary types of incandescent lamps to such customers, the new Tantalum lamp is at present too costly to be included under this offer. The retail price of this lamp is 60 cts. Those purchasing electricity from the company according to the wholesale forms of contract may procure the lamp at the net price of 48 cts. The tantalum lamp requires 44 watts and gives 22 c. p.; this is 12% less power than that consumed by the ordinary 16 c. p. incandescent lamp with 37½% more light.

A NATIONAL DRAINAGE CONGRESS has been called by the Hon. Frank Frantz, Governor of Oklahoma, apparently at the request of the Chamber of Commerce of Oklahoma City. The proposed date for the Congress is Dec. 5-7, 1906. Each state and territory is invited to send ten delegates, besides which, cities, counties, drainage districts, and agricultural, irrigation and trade organizations are invited to send representatives. The call states that

the objects of the conference will be the discussion of those phases of the drainage question which are of common interest to all, the consideration of ways and means for the inauguration of a general movement for the reclamation of lands by the construction of drainage works, and to start a campaign of education for the purpose of enlightening the popular mind upon this very important subject to the end that public sentiment may be prepared to endorse and support the adoption of a practical and definite line of policy pertaining thereto.

The Oklahoma City Chamber of Commerce makes statements of its own regarding the business of the conference and its relation to Oklahoma, as follows:

In requesting the Governor of Oklahoma to issue the call for such a conference in his official capacity we acted advisedly, having consulted with a number of state engineers and drainage officials as well as interested officials and engineers in the several branches of the Federal government service. In counseling such a course of action, it seemed to be the very general opinion that there was ample precedent for it in the organization of the irrigation interests of the arid region which occurred nearly a decade and a half ago. The results of the agitation and educational efforts of that movement are apparent in the splendid national irrigation act, under the operations of which the industrial development of the states of the arid region is eclipsing all previous records.

With many thousands of acres of land which will ultimately have to be reclaimed by the construction of drainage works, Oklahoma is to be admitted into the Union under an enabling act which makes no grant for drainage purposes such as was done for many of the other states of the central west. Her people therefore feel that they are peculiarly justified in proposing to make a common cause with the people of other interested states in aiding the inauguration of a general movement for land drainage reclamation.

It is stated that all railways will give a one-way fare plus $2 for the round trip. Those wishing further information should address A. W. McKeand, Secretary of the Chamber of Commerce, Oklahoma City, Okla. A slip sent out with the call states that there is a larger area "of land in the humid region to be reclaimed by drainage than there are acres of arid land that can be reclaimed by irrigation with the available water supply"; and also emphasizes the fertility and productiveness of drained lands, their freedom from drought, their beneficial effect upon both public roads and public health.

A REMARKABLE TYPHOID EPIDEMIC in the Village of Emmendingen, Germany, is reported by E. Seligmann, in the "Gesundheits-Ingenieur" of Oct. 6, 1906, as follows: In the latter part of 1905, three cases of typhoid fever occurred in three adjoining houses. The contents of the privy vault of one of these houses were used as fertilizer by a farmer in a neighboring village, and a short time afterward he fell sick of typhoid. His body clothing was washed in the brook flowing through the village, water from which is used for washing dairy-pails. The milk of the dairy in question thus became infected, and those families in Emmendingen which were supplied with this milk developed typhoid cases. It was observed that those persons who consumed the milk only when boiled remained unaffected.

THE MATERIALS USED FOR WATER SERVICE pipes in Massachusetts are given in detail in the report of the Massachusetts State Board of Health for 1904-05, which has just been issued. The inquiry was prompted, it seems, by a number of cases of lead poisoning through the use of lead service pipes in different cities, which have occurred in different parts of the State. A summary given in the report named shows that in 3 cities in Massachusetts all the service pipes are of lead, and in 23 other cities and towns they are chiefly of that material. In addition, lead or lead-lined pipes are used to a considerable extent in about a dozen other places. In 83 cities and towns no lead whatever is used. Plain wrought-iron pipe is used in 12 cities and towns, while in 53 the services are chiefly of galvanized iron and in 49 they are principally of cement-lined wrought iron. In Fairhaven tin-lined services are in general use, and they are also largely used in Kingston, Milford and Hopedale, where lead poisoning has occurred due to the use of lead service pipes; tin-lined services are also used to some extent elsewhere. For new services and for renewals, lead or lead-lined pipe is now used almost exclusively in 28 cities and towns, cement-lined pipe in 34, and galvanized pipe in 65 cities and towns. As would be expected, plain wrought-iron pipe has invariably given rise to "more or less trouble" from rusting, and "considerable trouble from this cause has been experienced in 44 places using galvanized-iron pipe." As many as 8 places report that cement-lined pipes have also given trouble from rusting.

PERSONALS.

Mr. Jacob Wirtner has resigned as a member of the Board of Water Commissioners of Dunkirk, N. Y.

Mr. J. H. Gregg, formerly Chief Engineer of the Link Belt Engineering Co., has accepted a position with Mr. H. A. Bishop, Contractor, Chicago, Ill.

Mr. J. W. Tysons has been promoted to the position of Secretary of the Washington State Railroad Commission, to succeed Mr. C. A. Snowden, resigned.

Professor G. W. Wilder, formerly in charge of telephone engineering work at the Armour Institute of Technology, has decided to take up consulting telephone engineering work.

Prof. R. L. Sackett has been appointed Engineer for the Indiana State Board of Health, and is making a sanitary survey in connection with the pollution of the White River.

Mr. A. G. Courtright, formerly with the Arnold Company, of Chicago, has accepted the position of Superintendent of Construction with the Electrical Installation Co., of Chicago, Ill.

Mr. W. G. Cummings has been appointed Manager of the Kansas City, Mo., office of the Ludlow Valve Mfg. Co., of Troy, N. Y. The new office is located at 204 the Dwight Building.

The following changes have occurred in the personnel of the Reclamation Service: Mr. R. S. Doerfling, Engineer; Mr. T. C. Callister and Mr. H. L. Eames, Engineering Aids, have resigned from the service.

Mr. L. E. Seas, formerly Estimator and Superintendent for Thompson & Starrett Co., New York City, has accepted a position as Estimator with the Jas. Stewart Co., General Building Contractors, St. Louis, Mo.

Mr. Alfred L. Hartridge, formerly Assistant Engineer of the Ocean Shore R. R., has accepted the position of Locating Engineer, Mountain Division, Grand Trunk Pacific Ry. His headquarters are at Hazelton, B. C.

Mr. L. F. Beers has been placed in charge of the Detroit office of the Buffalo Forge Co., to succeed Mr. H. M. Brightman, who is now connected with the Terry Bending Engineering & Construction Co., of Grand Rapids, Mich.

Mr. M. W. Mansfield, Superintendent of the Indianapolis & Vincennes Division of the Pennsylvania System, will become, on Nov. 1, Assistant Chief Engineer of the System, with headquarters at Pittsburg, Pa. He will be succeeded by Mr. J. W. Cooneys.

Mr. George K. Lowell, General Superintendent of the Chicago, Indianapolis & Louisville Ry., has been appointed General Manager of the Detroit, Toledo & Ironton Ry. and the Ann Arbor R. R., in charge of operation of both roads. His headquarters will be at Toledo, Ohio.

Mr. Horatio A. Foster, formerly Consulting Engineer, Philadelphia, Pa., has become associated with Mr. L. B. Stillwell, of 100 Broadway, New York, and has removed to Baltimore as Resident Engineer in charge of Mr. Stillwell's Baltimore office, 1314 Continental Building.

Obituary.

William Robertson, a contractor and builder of Jersey City, N. J., died at his home in that city, Oct. 24.

John Delany, Superintednent of Construction for the Detroit, Mich., Water Board, died in that city, Oct. 21, of pneumonia, aged 46 years.

Asher T. Meyer, President of the American Manufacturing Co. and the Bridgeport Tube Works, died at his home in New York City, Oct. 22.

George A. Crocker, M. Am. Inst, M. E., died at New York City, Oct. 20, aged 75 years. He was a member of the firm of Crocker Bros. and a director of the Virginia & Southwestern Ry. and the Virginia Iron, Coal & Coke Co.

Arnet Stone McBroom, Assistant Engineer of the Gulf, Colorado & Sante Fe Ry., died at Temple, Tex., Oct. 18, of typhoid fever. He was a graduate of Purdue University, class of 1901, and was formerly employed by the Westinghouse Electric & Mfg. Co., of Pittsburg, Pa.

W. T. Jennings, M. Inst. C. E., a well-known engineer of Toronto, died suddenly at Lansing, Mich., Oct. 24, aged 60 years. Mr. Jennings was born at Toronto, and started his career as a civil engineer on the Canadian Pacific Ry., advancing to the position of Resident Engineer of Toronto. From 1890 to 1892 he was City Engineer of Toronto, when he resigned and opened offices in that city as a consulting engineer. He was a Past President of the Canadian Society of Civil Engineers and an Honorary Examiner of the School of Science.

ENGINEERING SOCIETIES.

COMING MEETINGS.

ROADMASTERS' AND MAINTENANCE OF WAY ASSOCIATION OF AMERICA.
Nov. 13-15. Annual Meeting at Chicago, Ill. Secy., C. E. Jones, Beardstown, Ill.

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS.
Dec. 3-4. Annual Meeting at New York City. Secy., W. Everett Parsons, 12 Bridge St., New York, N. Y.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
Dec. 4-7. Annual Meeting at New York City. Secy., F. R. Hutton, 12 West 31st St., New York, N. Y.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.
Dec. 27 -Jan. 2, '07. Annual Meeting at New York City. Secy., L. O. Howard, Cosmos Club, Washington, D. C.

THE ENGINEERS' CLUB OF CENTRAL PENNSYLVANIA.—The club enjoyed the first excursion of the season, Saturday, Oct. 27. A special train left the Reading station at Harrisburg, Pa., at 8.10 a. m., making stops at Minersville, Cornwall and Lebanon, Pa., where the plants of the Lackawanna Steel Co., the Pennsylvania Steel Co., the Lackawanna Iron and Steel Co., the Lebanon Chain Works, the Weimer Machine Works Co., and M. H. Treadwell & Co. were inspected. En route homeward, the party made a short stop at Rutherford to inspect the large freight yard located there, which is used by the Philadelphia & Reading Ry., the Pennsylvania Co. and the Western Maryland R. R.

PERMANENT WAY INSTITUTION (England).—The opening meeting of the 1906-1907 season was held at the Mansion House Station, in London, on Oct. 9, about 25 or 30 members being present. The greater part of the time was occupied by a discussion on the proposed incorporation of the society and a revision of its constitution and by-laws. A paper on the summer meeting and excursion, held at Newcastle, was read by Mr. C. L. Hollands (Signal Inspector of the London, Brighton & South Coast Ry.). Mr. E. E. R. Tratman, Associate Editor of Engineering News) was present by invitation and made some brief remarks relative to English and American track or "permanent way." The award of the gold, silver and bronze medals for the three best papers presented during the 1905-1906 season was announced as follows: "The Electrification of Permanent Way," T. Ridley, Northeastern Ry.; "Pile Driving," J. E. Taylor, L. B. & S. C. Ry.; "An Explanation of Drawing Scales," E. J. J. Swindell, Great Central Ry.

The institution has about 800 members in Great Britain and the colonies, and is composed mainly of permanent way inspectors (or roadmasters) and railway engineers.